AGRICULTURAL ENGINEERING

Published by the AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

Executive Office of the Society: Saint Joseph, Michigan.

SAMUEL P. LYLE, *President* RAYMOND OLNEY, *Secretary-Treasurer*

VOLUME 19 OCTOBER 1938 NUMBER 10

CONTENTS

EDITORIALS 421

A PROFILE OF FARM ELECTRIFICATION IN AMERICA 423
By G. A. Rietz

PORTABLE VALVE METER FOR MEASURING IRRIGATION WATER 428
By J. E. Christiansen

FUNDAMENTAL CONCEPTS OF AIR CONDITIONING 429
By R. L. Perry

AN ELECTRIC DRAWBAR DYNAMOMETER 431
By Harry L. Garver and F. A. Brooks

WHAT INDUSTRY EXPECTS OF PUBLIC RESEARCH AGENCIES 433
By H. W. Gerlach

TILLAGE IN RELATION TO WEED ROOT SYSTEMS 435
By E. A. Hardy

RUNOFF FROM SMALL DRAINAGE BASINS 439
By D. B. Krimgold

WHAT AGRICULTURAL ENGINEERS ARE DOING 447

NEWS 448

AGRICULTURAL ENGINEERING DIGEST 456

Published monthly by the American Society of Agricultural Engineers. Publication office at Benton Harbor, Michigan. Editorial and advertising departments at the executive office of the Society, St. Joseph, Michigan . . . . Price $3.00 a year, 30 cents a copy; to members $2.00 a year, 20 cents a copy. Postage to countries to which second-class rates do not apply, $1.00 additional . . . . The Society is not responsible for statements and opinions contained in papers published in this journal; they represent the views of the individuals to whom they are credited and are not binding on the Society as a whole . . . . Entered as second-class matter, October 28, 1933, at the post office at Benton Harbor, Michigan, under the Act of August 24, 1912. Additional entry at St. Joseph, Michigan. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized August 11, 1921 . . . .
The title AGRICULTURAL ENGINEERING is registered in U. S. Patent Office. Copyright, 1938, by American Society of Agricultural Engineers.

Pickled Grass

ENSILAGE cutter blower pipes are this year carrying more legumes and grass into feed storage than ever before. The practice of ensiling these crops is spreading among livestock raisers on its evident merits. Its ultimate economy will depend largely on the nutritional optimum percentage of ensilage in the total diet of farm stock, on the potential yield and quality of ensilage from various grass and legume crops, and on handling economy. These factors are interrelated and indicate a clear field for co-operation between agronomists, animal husbandmen, and agricultural engineers.

AGRICULTURAL ENGINEERING

VOL 19, NO 10 EDITORIALS OCTOBER 1938

Engineering Redefined

ACCORDING to an editorial in the current issue of "Mechanical Engineering," the definition of an engineer has recently been brought up to date by that distinguished leader in the profession, Dr. Karl T. Compton.

"An engineer" he says, "is one who, through application of his knowledge of mathematics, the physical and biological sciences, and economics, and with aid, further, from results obtained through observation, experiences, scientific discovery, and invention, so utilizes the materials and directs the forces of nature that they are made to operate to the benefit of society. An engineer differs from the technologist in that he must concern himself with the organizational, economic, and managerial aspects, as well as the technical aspects of his work."

Agricultural engineers will note with satisfaction Dr. Compton's specific inclusion of the biological sciences as a field of knowledge available for engineering application. Whether or not the definition was written with a specific view to including the field of agricultural engineering, it could scarcely be improved from that standpoint.

Biologic materials are notably the stock in trade of agriculture. Living cells may reasonably be looked upon as organic processing equipment. Their processing capacity depends not only on their inherent characteristics, but on the working conditions to which they are subjected and the raw materials with which they are supplied. The forces and materials of nature, both within and surrounding the God-given chemical converter, are subject to varying degrees of human control for operation "to the benefit of society."

Determining and modifying the characteristics and responses of living matter to forces and conditions is biologic science. Determining and teaching the principles of organization and application of this knowledge of organic potentialities for efficient agricultural production, with the aid of all the other scientific knowledge and engineering applications that can be brought to bear on the problem, to meet the most human needs at the lowest human cost, is agricultural engineering. The practice of these principles is farming at its best.

Dr. Compton indicates that an engineer concerns himself further "with the organizational, economic, and managerial aspects" when he "so utilizes the materials and forces of nature that they are made to operate to the benefit of Society." In other words, he gives thought to related factors influencing the practical application of his technology. He himself supplies some or all of the common sense direction of his technological efforts so that the result may be more practical than one of the mechanical extravaganzas invented by that great teacher of what not to do in engineering, Rube Goldberg. His mind is on the achievement of human, practical, socially desirable results, and his technology is a respected means to those ends.

This phase of the definition, too, fits agricultural engineers. Their very existence as a new adjunct to an old occupation grew out of a real need and opportunity which they have had to define, explain, and justify. They deal with efficiency and dependability in the production of materials for such basic human values as food and clothing; with the conservation of human life and energy, as well as natural resources. Their technological problems are not handed to them ready-made. The scientist talks of what is scientifically possible; the farmer in terms of the results he wants; and other engineers in terms of what is being done in other engineering fields. The agricultural engineer must interpret these viewpoints and fields of knowledge into his own technology; develop their possibilities and reinterpret their results into equipment, materials, and methods which farmers can afford to use and can and will use. The agricultural engineer, whether in public service or private industry, knows that, to be truly successful, his work must pass the supreme test of acceptance and use by those hardheaded farmers who have successfully avoided mortgage complications or who are getting ahead by their own efforts in spite of such handicaps. In addition to developing the principles of biologic production from the standpoint of biologic efficiency, agricultural engineering necessarily involves developing the principles, and methods of organization, production economics, and management for overall farm efficiency. The two are inseparable considerations in achieving the results agricultural engineers seek.

From the standpoint of agricultural engineers therefore, Dr. Compton's definition of an engineer should prove highly acceptable.

Handbook Considerations

LIKE projected rocket flights to the moon, the matter of an agricultural engineering handbook is a recurring subject which has not yet reached the stage of practical achievement. Some complicated technical, publishing, and financing problems are involved. It seems likely, however, that if the technical problems can be solved to the extent of compiling a body of clear, accurate, and appropriate copy, the publishing and financing problems might be simplified by the elimination of several unknowns.

To be widely useful and worth its cost the handbook should represent the desires of a large representation of agricultural engineers. Presumably the greatest need is for a compilation of data frequently used by agricultural engineers but not readily found in other engineering handbooks. This might well include information on the underlying science, application data, materials and equipment, and operating methods and practices available for application or recommendation by agricultural engineers.

Geographical area data as to temperature, precipitation, soils, and crops might be included. A body of data on the biologic requirements of specific crops and types of livestock, so far as those requirements impose limiting conditions on engineering applications, would be highly useful to agricultural engineers. It might gradually be compiled as such data is established, and would seem appropriate to an agricultural engineering handbook.

Legal requirements as to sanitation and public safety involved in agricultural processes and equipment could be included. Engineering data on commercially available farm equipment, especially current models, would be desirable information. Reports of recent Nebraska tractor tests, for example, could be reprinted for convenient reference.

This range of subject matter could be treated, to some extent, with a view to applications in agricultural engineering practice in research, extension, resident teaching, design, development, and farming practice. In other words, information on available engineering material and techniques for agricultural engineering research, for example, might be as valuable to research agricultural engineers as the application data resulting from completed research.

It is evident that an agricultural engineering handbook could easily grow to unwieldy proportions. Discretion will be necessary to limit it to the most desirable amount of information most widely useful to agricultural engineers.

The development of a handbook is progressive. At present the projected agricultural engineering handbook seems to be in that stage of progress in which it would profit most by a lively professional interest in choice of subject matter.

Seasonal Watershed Data

ENGINEERS interested in soil and water conservation in any way will be heartily in accord, we believe, with the U. S. Soil Conservation Service policy of making available at the end of each precipitation season its coordinated data on watershed characteristics, precipitation, and resulting runoff. This policy, and the reasons for its adoption, are stated in the annual meeting paper of D. B. Krimgold, published in this issue.

The runoff studies on S.C.S. demonstration projects represent a long-time program to obtain, better late than never, hydrologic information which is urgently needed now, but for the obtaining of which the necessary public support has not been previously available. It is pointed out that these data are not being obtained for determining the effects of various practices. They are basic correlations of natural phenomena which recur at irregular intervals under similar conditions over large and important areas of the United States. They are factors in the cost, effectiveness, and reliability of engineering works for soil and water conservation, water supply, drainage, and flood control. They are factors, lack of accurate knowledge of which leads to overdesign and high cost, and to underdesign, failure, and ultimate high cost.

Engineering construction for human convenience and the conservation of natural resources is going forward. It can not wait thirty, fifteen, or even five years for the ultimate in watershed data with which to work. Data released as obtained will be a valuable addition to the limited existing data, in the planning and design of current works. Data released serially will be followed, appreciated, and understood more fully than a momentous tome climaxing several years of secretive research. Experimental applications of early data, paralleling the accumulation of further results, should aid in their understanding, final analysis, and subsequent applications. Moreover, the data will not be of a nature that is easily subject to popular misuse, or that is apt to encourage ill-advised promotions or speculations. In fact, it will be dry as dust to anyone but engineers who are working with structures influenced by runoff. To them it will be a means of improving their professional service.

From any and every angle that has come to mind, the early publication of this data seems advantageous and in the public interest. We commend the Soil Conservation Service both for going after this basic information and for adopting a farsighted policy of making it available as it is obtained.

Heat on Haying

THE SUN of agricultural engineering interest is shining brightly on hay making. A belief is widespread that there is still considerable room for improvement in cost of production, quality, and safety from spontaneous combustion.

All the main technical divisions of agricultural engineering are interested. The equipment involved interests not only the power and machinery group, but also, from the standpoint of stationary power, the rural electrification men. The storage conditions and safety from spontaneous combustion are obvious farm building factors. And anything that is accomplished to make forage a more attractive farm crop may be expected to further the cause of soil conservation.

The drying problem is being approached with variations of field drying practice, mower crushers, partial field drying, complete artificial drying, ventilation of storage space, and ensiling to avoid the necessity of drying. Drying on the refrigeration principle, using solid carbon dioxide, which may also be used to exclude oxygen, is being tried. Drying in vacuum chambers has at least been seriously suggested.

Hay is being chopped both at the mow and at the mower. Various loading, hauling, and unloading combinations are being tried. Loose hay, baled hay, chopped hay, and ensiled forage all have their backers in the race for low storage and handling costs.

The range of possibilities which have been on trial for some time without notable advance in general farm haying practice suggests the desirability of a fairly thorough review of the physical science and related production economics involved. Some energetic backtracking from experimental and development work into the pure science principles of moisture transfer, heat transfer, and air circulation might reveal some new leads to their practical application in forage handling.

From the standpoint of comparative costs and values there seems to be room for more research in production economics, involving timeliness, crop loss, handling waste water, storage costs, labor, equipment and operating costs, value of product, variety of feed types required, and adaptability of production plans and equipment to meet changing conditions.

Forage plants and plant varieties are being studied. Animal nutrition specialists are getting closer to quantitative specifications for feeds to meet definite animal-production objectives. The agricultural engineer is the go-between in a position of responsibility to put the biological potentialities of crop varieties on an economical farm production basis to meet whatever feed condition requirements the nutrition specialists may define.

A Profile of Farm Electrification in America

By G. A. Rietz

I SINCERELY believe that the hard work and inspiration of agricultural engineers, stimulating and guiding the institutions and organizations with which we are associated, has been and can continue to be the outstanding driving force for the sound development of farm electrification in this country.

Every agricultural engineer is an apostle of better methods and equipment for agriculture. We are interested in any movement which will improve either business conditions or living conditions on the farm. Is it any wonder, then, that we are so vitally interested in farm electrification, which we know can be made to improve so materially both these conditions?

Agricultural engineers for years have gone about their work in a quiet, businesslike manner. That is our way of meeting and solving our problems. But as more and more groups have become interested in farm electrification, it has become more confusing to many. Then, too, we are inclined to get so involved in our particular job that we may lose sight of the big objective of the entire undertaking. We are so close to the trees that we cannot see the forest.

The title, "A Profile of Farm Electrification in America," directs us to examine the over-all subject, and to do it from a distance, so that we can make a rather complete observation and evaluation.

I should like to examine with you the important features of the profile of farm electrification. And let us also examine those facts and truths that support all sound engineering thinking.

The three prominent features of this profile are (1) the farm family, (2) industry, and (3) educational and research groups.

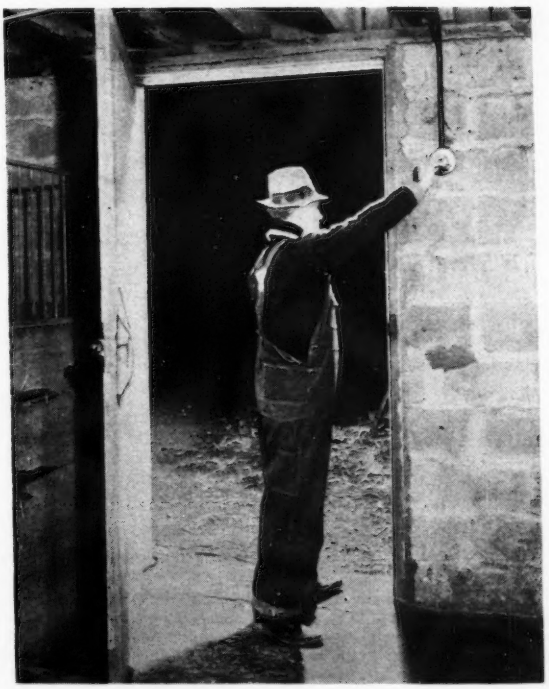
Let's first consider farm families. A dairyman in Washington says, "I wouldn't try to operate a dairy farm without electricity. It makes for the success of our farm and every other farm where it is used in the right way." Listen to a farm wife in Texas: "We enjoy the luxuries of the rich in our farm home, and at a cost in keeping with our moderate income. We now have all the conveniences that any home can have. The children are growing up under an ideal environment. We are proud and happy to be farming."

A poultryman in New York said to me, "I am now running my poultry farm as I might run a factory. Modern electric equipment and methods have removed many of my gambles and losses and have enabled me to place my farm on a more businesslike basis."

A general farmer in Michigan says: "I solved the hired-man problem on my farm. My farm is my living—120 acres, stock, grain, and dairy—and I have to make it pay. The uses I make of electricity in farm production save me the time of a hired man, do the jobs better, and allow me to work independent of outside help. Electricity in the home has also made things a world easier for my family. Thanks to electricity, we now really enjoy farming."

Electricity brings to the farm a new force which the farm family can use to bring about many desirable changes. These are typical of the experiences and statements of thousands of American farm families who have done just that. In fact, more than 1¼ million American farm families have the same opportunity, as they are now receiving electric service from power lines. Electricity is being brought to thousands of other farms each year. The job is by no means completed. Progress may appear slow to some, but there are many problems and obstacles—problems that are present in every worthwhile undertaking. More and more farms are getting electric service every year, and we are constantly increasing the usefulness of electricity to each farm family.

Let us now take cognizance of one vitally important point, probably the most important fact about farm electrification. Unless farm families can derive profits and benefits that are worth more than their cost, we have not established farm electrification on a sound basis. When I use the word "profit," I use it in its broadest concept: Money profit, happiness, easing of burdens, and the joy of living on the farm. Many people evaluate progress in farm electrification in terms of the number of farms served by power lines. Dr. E. A. White has for years properly defined farm electrification as electricity at work on the farm. Merely having electric service available is much like having money buried on the farm—it can do little good unless it is properly used. We do not expect farm families to use electric power except where it will produce real benefits and profits for them. However, the great majority of farm customers apparently do not yet realize that electricity will produce further profits for them if they give it more jobs to do. Far too many are inclined to



An address before the annual meeting of the American Society of Agricultural Engineers at Asilomar, Pacific Grove, Calif., June 28, 1938.

Author: In charge, rural electrification section, General Electric Co. (Mem. A.S.A.E.)

use electric service somewhat as they used their automobiles in the early days. That is, they purchased a car and kept it in the garage except for use on short pleasure trips Sunday afternoons, and only on those Sunday afternoons when it did not rain.

We have a tremendous job of assisting farm families in planning for the full and intelligent use of electric service. Only through full use will they get the benefits they should have. They will also profit by constantly earning lower rates for electric power. This program does not require a tremendous investment in any one year. It should be a soundly planned program, in which additional profit-producing electric equipment is purchased only as fast as it can be properly financed.

Let us consider the place of various industries in the farm electrification profile from three important angles, namely, (1) how farm electrification fits in industry, (2) whether its growth has been sound and reasonable up to this point, and (3) whether this growth will continue.

Since Edison's small beginning in the Pearl Street Station, New York, in 1882, the history of the electrical industry has been one of constant growth in order to serve an ever-increasing number of more-scattered customers. At first his business consisted entirely of lighting stores, important streets, and commercial establishments along those streets in a small, concentrated section of New York City. For several years he increased his sales field by convincing others in the same concentrated section of the city that their establishments should be lighted with the electric lamp. Nearly every lighting company likewise started in small areas.

Several years later the electric motor was introduced as a better source of power for small industrial operations. This increased the use of electricity and the profits from that limited section. The lighting company was then tempted to extend its lines and to speculate with serving outlying businesses and adjoining residences—more scattered customers.

At first there was not enough revenue from these new, scattered customers to justify serving them. However, the building of lines in those areas went on slowly and profits from customers in the concentrated areas kept the company solvent.

Fortunately, developmental work soon produced other uses for electricity among both old and new customers, and the increased revenue from these combined sections made possible a further venture—this time into the purely residential section of the city. As this area became adequately served with lines and a greater public acceptance developed, the companies ventured into the suburban sections of the city—another sparse customer section.

It is to be noted that the development of each new section was a speculation, and that the investment had to be recovered before the next step could be taken. For the company to remain financially sound, undeveloped areas could be added only in proportion to the ability of the company to finance such extensions.

By 1906 the industry had developed, in addition to the lamp, devices such as the flatiron, toaster, range, coffeepot, and fan for domestic use. An awakening of public interest produced a market anxious to receive service as quickly as the service companies could supply it.

We know that as early as 1905 some of the more venturesome companies undertook to make short extensions into purely farm territory, and that as early as 1908 electrical manufacturers were investigating the services electricity could perform for farm families.

It is easy to see how rural electrification was and is a natural undertaking of the industry. Its growth is not at all different from the increase in electrical customers and

INEFFICIENT WAYS OF USING THE MOST EXPENSIVE FORM OF POWER—HUMAN ENERGY

Pioneer conditions enforce an industriousness of hard manual work and a thrift of doing without. In many of our farming areas the pioneer stage has passed. There the concepts are gradually and properly changing to an industriousness of accomplishment and a thrift of human values, of doing with every aid within reach. It is a part of the agricultural engineer's work to help farmers conserve human values by making available improved materials, equipment, methods, and working conditions, and by showing farmers how to use these aids; to apply their mental and bodily energy to directing the efficient accomplishment of purposes with materials, methods, equipment, and forms of power which are less limited in variety, capacity, and adaptability, and less costly in the long run

of the uses of electricity in our cities and towns. In each case industry has carried on an immense amount of work to discover and develop new, practical uses of electric service for each class of customers, as well as to improve further the existing equipment and applications. You may view the research and engineering programs as only selfish undertakings of the industry, but we must remember that they have provided the only means of extending the benefits of electricity to more and scattered customers and at lower cost.

When an electric line in a city or small town was built, between 50 and 150 individual customers could be connected to each mile of line. However, the same mile of line built in the country would serve only from 3 to 10 customers; therefore, this represented another and an extremely venturesome step for the industry. The greater investment per customer was prohibitive unless and until there was some assurance that each farm customer would use electricity considerably in excess of that needed in the farm home. This should not be interpreted as a lack of desire to serve farm customers but rather as merely the same reasonable and businesslike procedure followed in the cities and towns. As a matter of fact, more than 100,000 farms had been connected to power lines, as a speculation on the development of this market, before farm groups became interested in electricity.

It is not necessary to review the thorough study of farm electrification begun in 1923 by the four interested parties—farmers, power companies, manufacturers, and state and federal agencies. By 1926 the results of this work indicated a justification for extending service to more farms on a carefully selected basis. As you know, 1926 marked the beginning of the extension of power lines into farm areas on a much enlarged scale. Starting with something more than 200,000 farm customers in that year, the number has grown until today more than 1¼ million farms are connected to power lines. During that period the growth curve has been similar to that of residential customers in former years. It suffered no setback during any year, but, naturally, the growth was slower from 1932 to 1936.

In many of our states where factors are most favorable, between 50 and 90 per cent of the farms are now connected to power lines. As a matter of fact, in 18 states more than one out of every three farms have electric service from a power line.

In a large number of states, particularly through the South, Middle West, and Rocky Mountain areas, the percentage of farms having electric service is much smaller. There are many factors responsible for this condition, such as the small number of farms per mile, a high percentage of tenant-operated farms, a predominance of large specialty field-crop farms, many poor agricultural areas, and the fact that there are few large city and industrial centers producing sufficient electrical revenue to allow speculation in farm lines on a large scale.

Of course, we can do little about increasing the density of farms, but an influx of farmers or city families and greater use of electricity by each farm will qualify some of these areas for lines in the future. Nor can much be done where a majority of the farms consist of poor land or are operated by tenants. However, where a small number of tenants are interspersed among owners of good land, the number of good tenants desiring electric service, together with greater use on each farm, will justify many lines.

It is unfortunate that electricity has not already been adapted to field operations, such as plowing and cultivating. If it were, the resulting load would, in many sections, justify thousands of additional miles of farm lines. Good work has been done on this problem, and in time it may be solved. However, we must face the fact that at present large specialty-crop farmers can make relatively little use of electricity except in their homes. They have little livestock and perform few stationary operations in the farm yard. We must find more profitable ways of doing many of our farm jobs electrically.

Farm lines generally are not self-sustaining during their first several years of operation. In most sections city residents are helping support farm lines. However, building farm lines indiscriminately, either through public subsidy or by overspeculation, is unsound. Both private utilities and the Rural Electrification Administration must carefully determine the farms to which service can be brought. They must build lines judiciously to sections offering the most immediate revenue, not only as a sound business practice, but also to prevent development of large, extremely unprofitable areas which would become "white elephants" and weaken rural electrification's financial stability. During periods of less prosperity, further progress might suffer major setbacks if unsound practices were followed.

Have you ever thought about how many farms there are that, although they are on existing farm lines, have never taken the service? Nearly 300,000 farms right on those lines, but not connected. Maybe we can get a better idea of how many farms that represents. That's as many as the total of all farms in the five states of California, Oregon, Washington, Nevada, and Arizona combined. The three principal reasons they are not taking service are (1) lack of desire for the service, (2) inability of the family to pay for wiring the farm, and (3) many are tenant farms which the owner does not choose to have connected.

Lines should not be built too much in advance of the farmers' readiness for the service. Our development work to date justifies thousands of farm lines that have been built. However, research and development work must indicate the areas in which other farm lines can be built. It

must keep in step with expansion programs if farm electrification is to make healthy progress.

We believe in farm electrification. We know that its sound growth requires that the farm customer receive uninterrupted, high-quality service. Then he may profit, as industry is profiting, by using it in his business of farming, as well as for comfort and convenience in his home. Unless the farmer is assured of continuous, high-quality service, he cannot risk depending on it. You can imagine what interruptions of electric service would mean to a poultryman with brooders and incubators, or a market gardener with soil heating and refrigeration, or a dairyman with a milk cooler and a milking machine. Neither the farmer nor the electric company can afford this type of service, for it will discourage the use of electric apparatus and appliances—the foundation on which the future of rural electrification depends. The economic and social success of rural electrification depends on the full use of the service by present customers. Therefore, the development of profitable equipment for the farm must be supported by assurance that power will be available at all times.

Manufacturers play an essential part in this activity. They are in a position to furnish many important services and to cooperate with all other groups, and they should do so. Their objectives should include the following:

1 To acquire a complete knowledge of rural living and the business of farming.

2 To develop and adapt equipment that will enable the farm family to make more profitable use of electricity.

3 To keep rural users of electricity continually abreast of the latest developments in appliances and equipment for the farm and rural home.

4 To work shoulder to shoulder with all agencies engaged in assisting farm families to get the most from their electric service.

Some of them are conscientiously pursuing these objectives. They are working individually as well as in cooperation with the other groups on engineering and developmental work of three general types: (1) The discovery of new uses for electricity on the farm, (2) the redesigning of farm machinery for electrical operation, and (3) the constant improvement of existing equipment.

They are producing many educational bulletins, movies, slide films, radio broadcasts, booklets, and advertisements to place important facts before farm families. They gladly work with other educational and research groups. There is, of course, room for considerable improvement in these programs. The greatest need is for a more concentrated and better organized effort to redesign stationary farm machines for electrical operation and to make it easy for farmers to purchase those more efficient machines. Everyone will profit from this. Farmers will save a tremendous amount of money and labor, as the new machines will be smaller and less costly, and will operate with less attention. Manufacturers will sell more machines, and the revenue from farm lines will be increased.

Having examined the place of the farm family and of industry in farm electrification's profile, let us examine the educational and research features.

Many of the public agencies, particularly colleges, extension services, and agricultural research groups, have been contributing tremendously to the sound growth of this activity. They occupy a place of responsibility in giving farm families a true understanding of this whole problem. Farm families need good advice and counsel on many important phases of farm electrification. We are in the best position to keep them from making costly mistakes in farm wiring, lighting, the purchase and use of equipment, and in many other ways.

Many need protection from unsound exploitation of equipment, as well as projects. They need guidance for the making of reasonable demands—a realization that purchasing electric service differs from practically every other farm purchase they make. It is a community undertaking and cannot be undertaken by individual action. Unlike buying livestock, a tractor, or other farm equipment, where the individual can act entirely independently of the neighbors, the purchase of electric service depends on community action. Whether a farmer can get the service, and what he has to pay for it, depends on whether his neighbors also take the service and use it.

The keys to future progress are the development of more profitable uses for electricity and a more general adoption of profitable uses by present farm customers.

Many agricultural colleges, experiment stations, and private groups have been engaged in research and development work for years. However, there is a real need for research and developmental programs on a much enlarged basis at our agricultural colleges, experiment stations, and through the U. S. Department of Agriculture. Unless this work is stepped up, in a well-organized way, it will soon lag dangerously far behind.

Likewise, most of our educational groups know that farm electrification involves a tremendous educational job. They are carrying the important information to farm families, arming them with the facts that are so necessary to determine wise action. That work, supplemented by similar programs of power companies and manufacturers, must produce a greater use of profitable equipment among both old and new customers. The guiding principle for this extension program by both commercial and educational groups must continue to be knowledge of the facts and the recommendation of only such actions as will produce net benefits for the farm family—only those things that you yourself would do if you were in the farmer's place.

We would mislead farm families if we should allow them to believe that lines will soon be built to bring electric service to them all. I don't believe that there are unlimited funds with which to build farm lines indiscriminately. Many of their neighbors are not ready for electric service. They would be shocked to know how many proposed lines are being held up because neighbors will not grant rights-of-way for the line. It would be equally misleading to imply that the extension of electric service to farms has about reached the saturation point. Our confidence in this development, its progress to date, and the large group of men and women engaged in its sound development, make us rather optimistic regarding its future. We of the Rural Electric Division of A.S.A.E. favor all activities that will accelerate this program, but we caution against many of the suggested short-cuts to success. A big job lies ahead; it will take years of hard work. We shall meet many obstacles, and we can't wish our way over them. It will take patience and ingenuity, which I am sure we have.

Many discussions of rural electrification have been criticized for having failed to touch on the subject of power costs or rates. Let us examine that phase of the subject—not in the language of rate experts or engineers, but in common, understandable terms.

Many believe electric power is expensive. As a matter of fact, it is cheap. The point is that no matter how little

anything costs, it is expensive if the prospective buyers are not sold on its benefits.

Cigarette smoking is taken for granted; smokers say it produces very definite benefits—relaxation, fellowship, aid to digestion, etc. Costs are low. Sometimes we light a cigarette, lay it down, and forget it—and are not concerned about the waste. We offer cigarettes to our friends and think nothing of the cost.

Yet, as a matter of fact, during the time a cigarette is burning (not being smoked, but wasted) we can burn eleven 100-watt lamps for the same cost. While we are smoking the cigarette (puffing it), which consumes it faster and which produces the benefits we are after, we can burn (for the same cost) these eleven 100-watt lamps plus nine 100-watt lamps—a total of 2000 watts.

Now, 2000 watts is nearly 3 horsepower. It represents the total power demand of about 20 refrigerators, or 12 washing machines, or 25 radios, or 40 fans, or 1000 electric clocks.

To one who knows the benefits of these modern electric servants, there is no question as to how much more beneficial they are than cigarette smoking. The first we think expensive; with the latter we practically forget the cost. It's a matter of understanding the benefits.

Of course, you can argue that while it may be true that you can burn 2000 watts all at one time at a cost no greater than that of puffing a cigarette, you don't smoke cigarettes continuously. Neither would you burn 2000 watts in the home continuously.

As a matter of fact, speaking in averages, the average home can be completely light conditioned—light used whenever and wherever it is needed—for less than the average family cost for cigarettes—per day or per year.

We all know that American homes have come to depend on electric service and that the family gets many benefits from it. Yet how much did the average American family pay for all the uses they made of electricity in the home last year (1937)? Nine and one-half cents per day—about $2.90 per month—was the average American family's electric bill in 1937. That's much less than the average family's cigarette bill. It's just about what it costs the average American family for haircuts.

Thus we are talking about a product that is very cheap and that can furnish many benefits, but we must point out these benefits and look for more ways in which farm families can profit from using electricity more fully; for cost, in the final analysis, is not the important factor.

We have looked at the profile of farm electrification in America. We find the following:

1 Agricultural engineers have played a prominent role in its growth to date

2 They will probably be a dominant group in the future

3 Where farmers are using electricity fully and wisely, they profit far beyond its cost

4 Many agencies are conscientiously applying themselves to farm electrification

5 A real job has been done, but a big job lies ahead.

The value of reviewing what has been done is to give us the confidence and assurance of more accurately forecasting what may be done in the future.

Apparently there are four important needs that we must face, starting today, as follows:

1 The need for enlarged research and developmental programs

2 The need to redesign much of our stationary farm machinery for electrical operation

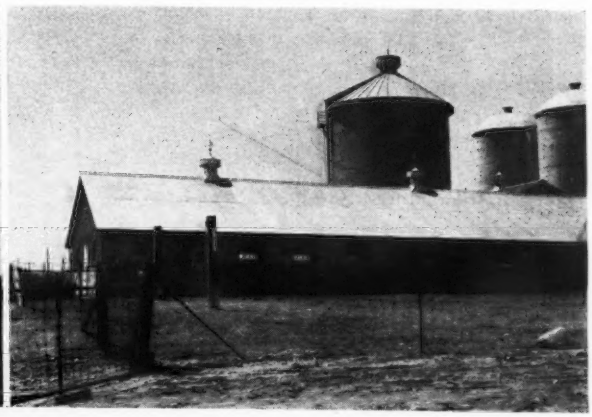
3 The need to continue to help farm families get greater profts through the wise use of electricity

4 The need for courage to work for sound development and to exercise good judgment.

It is always dangerous to place one's self in the position of a prophet. However, we all realize that the electrical industry is young, in spite of its record of accomplishment. The record is particularly outstanding in this country, where, with only 7 per cent of the world's population, we use more than 30 per cent of the electric energy produced in the world, and where electric power has multiplied the industrial workers' output forty fold. This reflects the results of years of intensive research and developmental work that have produced a multitude of undreamed-of uses for electricity in all fields, and have also made it possible to produce electric power at much lower cost. Those who have studied this subject very seriously feel that the future of the industry is much greater than its past.

Through full and wise use of electricity, it must become more profitable both to the user and the supplier. In a broader sense rural electrification is a vehicle for bringing better living to many people.

It is an undertaking which makes for better living, and we can be proud of our part in it. But those of us who are making it our life work must strive for farm electrification's sound development.



Portable Valve Meter for Measuring Irrigation Water

By J. E. Christiansen

FIG. 2 VALVE METER IN USE ON ALFALFA VALVE. FLOW, APPROXIMATELY 1.75 CFS

A PORTABLE irrigation meter for measuring irrigation water issuing from an alfalfa valve on a concrete pipe line (Figs. 1 and 2) has recently been constructed and tested by the Division of Irrigation Investigations and Practice of the College of Agriculture, University of California. It was originally constructed for the purpose of measuring water delivered to experimental irrigation plots, and was later improved and used for measuring flow in connection with a study of friction losses in concrete pipe lines. The desirable features of a meter of this type suggest its adaptability as a general-purpose irrigation meter where water is distributed through concrete pipe lines. Of course, it is not designed for measuring water for sale, but could be used for determining the quantity of water applied to a field, or plot, or for testing a pumping plant, or for checking the flow delivered to the farmer where other measuring devices are not used. The meter is placed in use by simply removing the valve lid and seating the meter on the valve. The register reads directly in acre-feet. An indicator hand makes one revolution for each 1/1000 acre-foot, so the meter can be used for measuring flow by simply timing this hand.

Author: Assistant irrigation engineer, University of California. (Mem. A.S.A.E.)

The meter was constructed from the register head of an old irrigation meter and a short length of 8-in standard pipe threaded on one end. A six-blade impeller was cut from a piece of heavy galvanized iron and securely fastened to the vertical shaft. A thrust bearing was provided at the top end of this shaft to take the upward thrust as the register head was designed for a downward thrust. No attempt was made to adjust the impeller blades so that the volume of water passed was correctly registered, although this undoubtedly could be done. Instead, the pitch of the impeller blades was arbitrarily set, and the coefficient to be applied to the readings to obtain the correct flow was determined by careful tests over a wide range of flow.

The tests were made in an outdoor water-measuring laboratory by comparison with a 2-ft rectangular contracted weir. A weir table, based on Cone's formula, was used for determining the flow from hook gage readings to the nearest 0.001 ft. Corrections were made for a slight leakage in the flume between the weir and meter, approximating one per cent. The flow as registered by the meter was determined by timing the indicator hand through ten or more revolutions, making three or more determinations for each test. Extreme care was taken to insure that equilibrium conditions were established after each change in flow before taking any readings. Two series of tests were made, the first with the valve spider removed from the valve, and the second with the spider in place in the valve. The results of these tests (Fig. 3) indicate that the spider has no effect on the registration, and that nothing is gained by removing the spider when using the meter. Because of the very small range in values of the coefficient through a wide range of flow, a mean value could be used without introducing an error of more than 2 per cent.

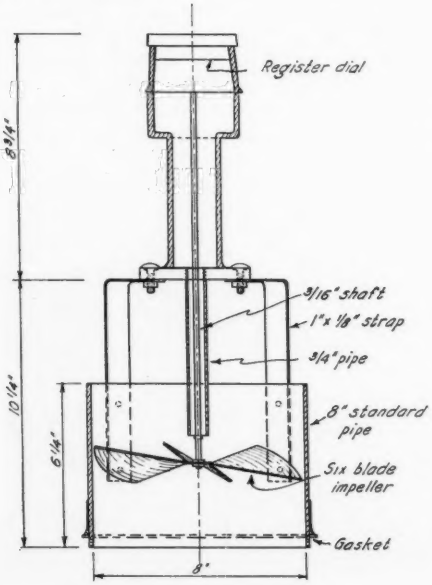
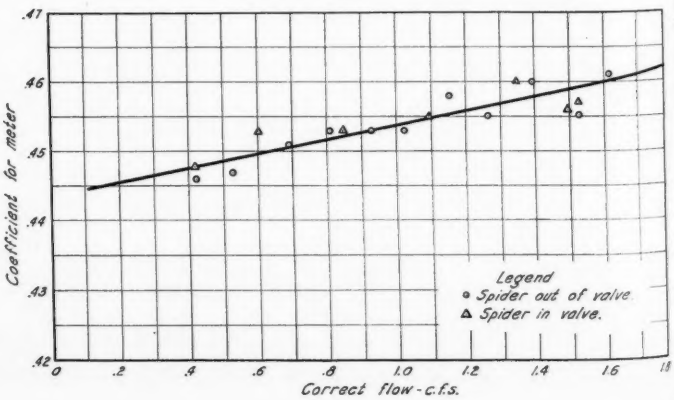


FIG. 1 (LEFT) VERTICAL SECTION THROUGH PORTABLE VALVE METER
FIG. 3 (BELOW) CALIBRATION CURVE FOR PORTABLE VALVE METER



Fundamental Concepts of Air Conditioning

By R. L. Perry

AIR CONDITIONING problems can be divided into two groups, namely, (1) what is required, and (2) how can it be obtained. Answers to the first question must conform to the "Code of Minimum Requirements for Comfort Air Conditioning", sponsored by the American Society of Heating and Ventilating Engineers and the American Society of Refrigerating Engineers, which says that, if the term "air conditioning" is to be used, the system must be able to control the temperature, humidity, motion, and quality of the air within required limits. The first problem is, then, what are the limits?

For measuring comfort, the yardstick needs to be somewhat flexible. The term comfort has a subjective flavor. You can't tell me how I feel; you must ask me. And my answer may depend partly on whether I took in the night life last evening, whether my neighbor's dog howled in the night, or what I had for breakfast. Individuals vary in race, accustomed environment, nervous temperament, weight, clothing, and food habits, so that it cannot be expected that all will feel the same degree of comfort under any given condition.

The first attack was the attempt to determine the combinations of temperature, humidity, and air movement which would give equal sensory perceptions of temperature. All combinations of these three variables, which gave the same feeling of temperature as a saturated air-vapor mixture at 15 to 25 ft per min (natural convection), were said to have an "effective temperature" equal to the actual temperature of the saturated mixture. The term "effective temperature" might have been made easier to explain and use if the conditions giving the same feeling of temperature had been referred to an air-vapor mixture of 50 per cent relative humidity, rather than to a saturated mixture, which is seldom encountered and is never comfortable. In agreement with a general impression, it was found that above about 45 F (degrees Fahrenheit), with natural convection, a decrease in humidity gave the impression of a lower temperature. Below 45 F, a decrease in humidity gave the impression of a higher temperature. The reason for this is not clear, because the energy loss by radiation and convection is not appreciably influenced by humidity, nor is the evaporation loss affected under about 90 F.

It has been recognized that conditions of equal effective temperature are not necessarily conditions of equal comfort, except in the intermediate ranges of relative humidity between 30 and 70 per cent, or possibly 20 and 80 per cent.

Comfort in summer calls for a different set of conditions than comfort in winter. In winter, when people are ordinarily indoors, an effective temperature of 66 F is preferred by most, regardless of the outside temperature. Some may be comfortable at temperatures ranging from 3 deg below this to 5 deg above. (The dry bulb for an effective temperature of 66 F is 71.5 F for a relative humidity of 30 per cent, and 68.5 F for 70 per cent. The dew points are 36 and 58 F, respectively.) In order to maintain a relative humidity over 30 per cent at 71.5 F, humidification will be needed when the outside temperature is below 36 F.

In summer people move in and out more frequently, and seem to prefer then a somewhat higher temperature indoors than in winter, depending upon the time of occupancy and upon the outside temperature. For durations of 3 hr or more, effective temperatures of 71 to 73 F are preferred. Some may be more comfortable at as low as 68 F and as high as 75 F effective temperature. (The dry bulb for an effective temperature of 71 F is 79 F for a relative humidity of 30 per cent and 74 F for 70 per cent. The dew points are 44 and 63.5 F, respectively.)

One of the next significant investigations was the measurement of the energy dissipation from the human engine, at rest and at work. It was found that over the range of 60 to 90 F for a person seated, or 45 to 90 F for one working, the energy production did not change with temperature (being much greater for one working, of course, in proportion to the work rate). The method of energy dissipation changed markedly with temperature, as shown in the following table.

ENERGY LOSS RATES FOR A NORMAL PERSON SEATED AND AT REST

Method of loss	Heat loss at 70 F, Btu/hr	Heat loss at 85 F, Btu/hr
Radiation and convection	310	170
Surface evaporation	50	200
Respiration evaporation	50	40
Total	410	410

The effect of temperature upon the energy exchange by radiation and convection was about what would be expected. It was proportional to the difference in temperature between the person and his surroundings, ranging from a loss of 370 Btu per hr at 60 F, to a gain of 160 Btu per hr at 110 F. The heat transmission coefficient in effect was 0.72 Btu per sq ft per hr per deg F. The loss rate varies, of course, with the area of the individual, his clothing, forced convection, and radiation exchanges with surfaces which differ from the air in temperature. In the original tests the walls and air were kept at the same temperature. Appreciation of the importance of the radiation exchange has been increasing, and more recent work has tended to emphasize it.

The evaporation rate per unit area from a wetted surface is generally recognized to be proportional to the difference in partial pressure of water vapor at the temperature of the surface and in the adjacent air (air-vapor mixture), and to vary with the air velocity. The relationship may be taken incorrectly to predict that the lower the humidity, the greater will be the total evaporation rate. This is not true, because the total energy dissipation rate (up to an effective temperature of 90 F where real distress results) is practically independent of humidity, and the radiation and convection loss does not change with humidity. Consequently, the evaporation loss, which the body automatically adjusts to maintain the total loss when radiation and convection change, does not vary with

Presented before a joint session of the Farm Structures and Rural Electric Divisions at the annual meeting of the American Society of Agricultural Engineers, at Asilomar, Pacific Grove, Calif., June 30, 1938.

Author: Assistant professor of agricultural engineering and assistant agricultural engineer in the agricultural experiment station, University of California. Mem. A.S.A.E.

humidity. Thus the true picture is that, as humidity increases, the total evaporation rate remains constant, but the unit evaporation rate decreases and a greater wetted area results. It will be noted that evaporation can occur into a saturated air-vapor mixture if the temperature of the wetted surface is above the dew point of the mixture. In the effort to perspire enough to provide the requisite wetted area, an excess may be secreted at some points, running off uselessly. If, at high temperatures (above 90 F for a saturated mixture and natural convection, or 110 F and 20 per cent relative humidity) the evaporation rate cannot take care of the necessary heat loss, the heat generated is not dissipated, the body temperature rises, and the distress, not merely discomfort, results.

Another engineering relationship which is misleading if used without critical consideration of its applicability, is that the energy loss rate by convection and evaporation from a wet surface at constant temperature is determined by the wet-bulb temperature and the air velocity, and is independent of the dry-bulb temperature. This may be of interest in the problem of avoiding distress where men are working under extreme temperature and high humidity, where the high air velocity maintained to facilitate evaporation makes convection high in proportion to radiation. It is not valid under normal comfort conditions, where a small fraction of the body surface is wet and where radiation exchange is at least as important as convection because of low air velocities.

An increase in air velocity gives an impression of a drop in temperature because of the increased convection loss. The effective temperature is lowered roughly one degree by each increase of 100 ft per min. Velocities from natural convection and normal movement of occupants will ordinarily be from 15 to 30 ft per min. The Code recommends a maximum of 50 ft per min in the lower 5 ft of a room.

The feeling of a draft is given by a stream of air more than 2 or 3 deg colder than the average room temperature at low velocities, and more than ½ to 1½ deg colder at 100 ft per min. The upper limits are permissible only in rooms above 80 F, during the cooling season.

In regard to air quality, it is obvious that air-borne pathogenic organisms and noxious gases or fumes cannot be tolerated. Dust and odors are a matter of concern. The simplest way to handle the odor problem is dilution with outside air, from 5 to 15 cu ft or more per minute per person.

In brief, then, assuming air of suitable purity, there are two views of the relation between air conditions and comfort. One is that the feeling of comfort is the result of the effect of air temperature and vapor concentration on the nervous system. The other is that comfort results when a normal distribution of energy loss occurs. These two may be related, for a change in the loss rate affects the skin temperature.

Discussion of air-conditioning methods will be confined to comfort cooling, for heating has been practiced for many years and its basic principles are well established.

The first two steps in comfort cooling are insulation and forced air circulation. Insulation of moderate thickness will pay for itself in winter fuel savings in most climates, and in addition will make the home more comfortable in winter as well as in summer. Although insulation of walls may be difficult in existing homes, ceiling insulation can usually be installed readily.

Insulation is important not only in reducing the initial and the operating cost of air-conditioning systems, but also in making greater comfort possible. The product of air-volume rate times temperature rise must be large enough to take care of the heat inflow rate. A reduction in the heat rate makes possible a reduction in either air velocity, temperature change, or both, thus simplifying the air distribution problem.

Insulation alone makes for comfort during hot afternoons in regions where there is a considerable difference between day and night temperatures. Inside temperatures tend to vary only slightly from the average outside temperature, so that the home seems comfortably cool when the outside air temperature climbs. But without ventilation, the inside seems unbearably warm in the evening when outside temperatures have fallen appreciably.

Ventilation with night air is then a simple and effective supplement to insulation, particularly where an appreciable daily fluctuation occurs. The house is cooled during the night, and remains cool well through the hot part of the next day. Its average will be below the outside average, and its peak a great deal below the outside peak. The fan capacity should give from 20 to 30 air changes per hour.

In some cases the fan is arranged to circulate air through the attic during the day, to prevent an accumulation of energy from solar radiation on the roof. This is not so necessary with insulated ceilings and vented attics.

The finned-surface convector ("radiator") is used with well water, water recirculated through a cooling tower, or cooled with ice or mechanical refrigeration. The water usage is high unless the initial temperature is below 55 F. When the surface temperature is above the dew point, simple cooling is accomplished with no change in the air-vapor ratio, although the relative humidity rises as the temperature falls. When the surface temperature is below the dew point, cooling and dehumidification result. The cooled air can be considered to consist partly of initial air, and partly of air (air-vapor mixture) with a dew point equal to the temperature of the surface. The proportion of each depends upon the heat transfer coefficient of the surface, the air volume rate per square foot of surface, and the temperature difference. The surface required is a compromise between initial and operating costs.

With cooling-tower water, very liberal surfaces are necessary if the air is to be cooled within ten degrees of the wet bulb. The performance will be rather poor in humid climates.

With refrigeration, almost any desired condition can be obtained. If water-cooled condensers are used, the water usage will be about as great as if water were used directly in the finned-surface units, but lower air temperatures can be obtained, and cooling towers can be used for water economy.

The heat removed from the air can be computed simply from the volume rate, density, unit-heat capacity, and temperature drop. The heat given up by the condensed vapor can be determined from its initial heat from Keenan's empirical equation

$$h = 1059.2 + 0.45\,t$$

where h (Btu/lb) = heat content of low pressure vapor, above 32 F

t (deg F) = vapor temperature

and from the heat of the exit condensate. Or these heat quantities can be taken approximately from a psychrometric chart.

The air washer type of unit is used in many industrial and in some commercial installations. If no energy is added or removed from the water—so-called "adiabatic evaporation"—its temperature *(Continued on page 434)*

An Electrical Drawbar Dynamometer

By Harry L. Garver and F. A. Brooks

FOR many years engineers and others interested in the study of traction power have been seeking a simple, convenient dynamometer that can be placed between a tractor and its load, and which will directly give a true picture of the work being done. Such a device, if not bulky and unwieldy, would be of inestimable value to the research engineer. To be most useful it should show at a glance the amount of power being expended on the machine in question. It should, if desired, make a graphic record of power requirements for any specified time. It should integrate the work done over any desired time or area and have the record ready in such form that a lot of calculating and interpreting is not required.

This problem has been before the agricultural engineering staff of the University of California since 1930. As a first attempted solution a mechanical drawbar dynamometer, designed by F. A. Brooks, was built by C. E. Barbee[1] in 1932, using a variable crank-throw device to modify the speed of the landwheel shaft in proportion to drawbar pull. The speed needle of a speedometer attached to the variable-speed shaft gave the desired indications of instantaneous horsepower, and the odometer counter registered the total work. An improved design was built in 1935, but inherent mechanical difficulties pointed to the desirability of also investigating electrical and hydraulic integrating mechanisms. The fundamental conception of the dynamometer is the same for all three methods of obtaining the desired indications; namely, an output proportional to land speed is modified in proportion to drawbar pull. The integrated total over a given period then represents cumulative foot-pounds of work, and the rate of doing this work is an indication of instantaneous drawbar horsepower.

Presented before the Power and Machinery Division at the annual meeting of the American Society of Agricultural Engineers, at Asilomar, Pacific Grove, Calif., June 28, 1938.

Authors: Respectively, graduate student, University of California, 1937-38, and Investigator, Washington C.R.E.A. (Mem. A.S.A.E.); and associate professor of agricultural engineering and agricultural engineer in the experiment station, University of California. Mem. A.S.A.E.

[1]Associate in the experiment station, University of California.

This paper describes the design of the dynamometer utilizing electrical principles for indicating horsepower and integrating foot-pounds of work.

A separately excited, noncompounded, 32-volt, 1/3-hp electric generator was connected to a front wheel of a Farmall-12 tractor through a series of gears, the ratio of which was approximately 54 to 1. The regular shunt field coils were replaced with 5-volt coils. This arrangement permitted the use of an ordinary three-cell, lead storage battery as a source of constant field current with one volt to spare. The extra volt permitted some field control.

Since a separately excited, noncompounded generator will deliver a voltage proportional to its rotational speed, it became necessary only to design an external circuit in which total resistance would remain constant regardless of the value of electric current, if within the limits of the generator. For this purpose 12-gage cupron wire resistors were used. Cupron is a nickel-copper alloy which has practically a zero temperature coefficient. Size 12 was selected because it was believed desirable to select a size large enough to prevent the temperature from rising excessively. It is readily seen from this that with an external circuit in which resistance is constant and a generator in which voltage is proportional to speed, the total current will also be proportional to speed.

But rate of travel is only one of the factors of work. That portion of the total current which passes through the measuring devices must be proportional to pull, so that the combined effect of speed and pull is indicated on an ammeter.

The bridge consisted of two parallel resistors of equal value (1 ohm each), each equipped with a series of contacts over which carbon brushes moved. Each resistor had 50 contacts, or commutator segments as we called them. The brushes moved across the segments with the compression of the drawbar spring. As one resistance was increased, the other was reduced, thus causing an increase in the proportion of current passing through the instruments with the increase in pull from zero at no load to full value at full load. From Fig. 3 it is seen that the external resistance changes as the resistances of the two branches of the parallel circuit change. To compensate for this change a

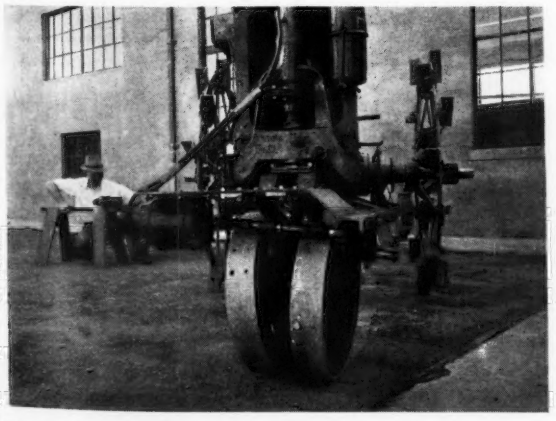


FIG. 1 GENERATOR MOUNTED ON FRONT WHEELS OF FARMALL-12 TRACTOR. IT IS DRIVEN BY ONE WHEEL THROUGH A SERIES OF GEARS

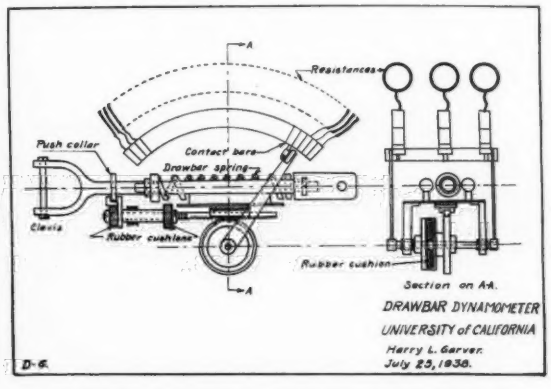


FIG. 2 SCHEMATIC DIAGRAM OF DRAWBAR LINK AND VARIABLE RESISTOR MECHANISM

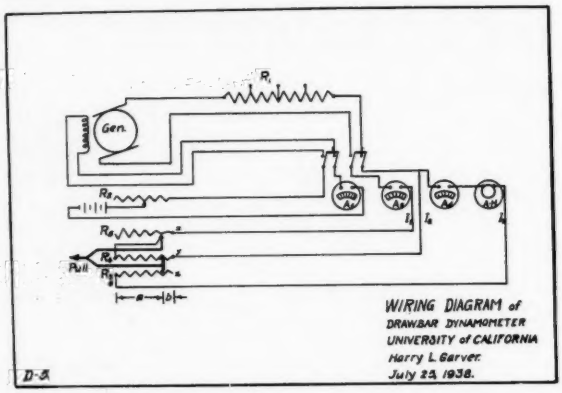


FIG. 3 SCHEMATIC WIRING DIAGRAM OF ELECTRICAL DRAWBAR DYNAMOMETER. AMMETER, A_4, IS INCLUDED IN THE CIRCUIT FOR TEST PURPOSES ONLY AND IS NOT ESSENTIAL TO THE DYNAMOMETER

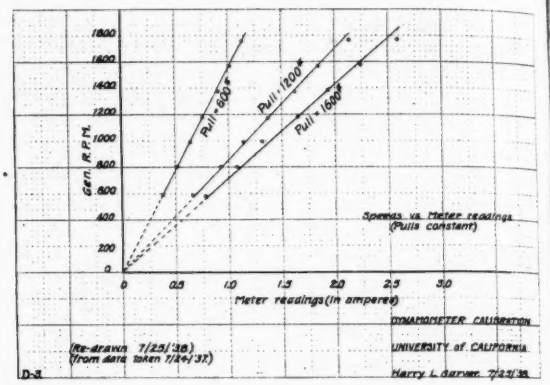


FIG. 4 SPEED VS METER READINGS. THE PULLS WERE HELD CONSTANT THROUGHOUT THE ENTIRE RANGE OF SPEEDS. THE CURRENT VALUES WERE TAKEN FROM AMMETER A_4 WHICH INDICATES VALUES OF I_3

tapered resistance was placed in series with the bridge. The same type of contact and brush scheme was used on this as on the other resistors, but the taps were so arranged that the total external circuit resistance remained constant.

The mechanical part of the device consists only of a spring type drawbar to which is attached a rack which in turn drives a gear. The rack is rubber mounted, and the gear drives the brush shaft through a second rubber damping device.

The selection of instruments was simple. Inasmuch as the electric current is proportional to speed and also to pull, all that is necessary is to measure the current. For this purpose the ammeter, one of the simplest of all electrical measuring devices, is used. A simple ammeter indicates instantaneous values of power. An ampere-hour meter automatically introduces the time factor and integrates work done.

A brief analysis of the electrical circuit (Fig. 3) will give a picture of the principle involved in the operation of the dynamometer.

A well-designed, noncompounded generator will deliver a voltage proportional to its rotational speed. Hence,

$$E \propto \text{speed} = c \times \text{speed}$$

$$R_t = \text{total resistance} = \text{constant (by design)}$$

$$= R_g + R_1 + R_{5b} + R_{\text{brush }5} + R_{4a} + 1/\left(\frac{1}{R_{4b}} + \frac{1}{R_{3a} + (R_{\text{brushes 3 and 4}} + R_{\text{instruments}})}\right)$$

$$I_t = E_g/R_t = I_1 = I_2 + I_3 = c \times \text{speed}$$

(subject to maintaining R_t constant).

From this it is seen that values of current alone and not an *EI* relation need be considered in measuring generator output.

$R_1 =$ constant (by design)

$R_3 = R_4 =$ constant (by design)

Reference to the schematic wiring diagram will show that at no load the potential at o will be the same as that at y and also at x, hence no current will flow through R_3.

The position of the brushes will vary directly with the pull (assuming uniform deformation of the drawbar spring).

Hence, R_{4b} is proportional to pull, and R_{3a} decreases with pull; also $R_{3a} = R_4 - R_{4b}$.

Neglecting, for the moment, brush and instrument resistances

$$I_3 : I_2 = R_{4b} : R_{3a}$$

$$I_2 = I_3 R_{3a}/R_{4b}$$

$$I_1 = (I_3 R_{3a}/R_{4b}) + I_3$$

$$I_3 = I_1/\left(\frac{R_{3a}}{R_{4b}} + 1\right)$$

But circuit 3 contains the fixed resistances, $R_{\text{instruments}} + R_{\text{brushes 3 and 4}}$.

$$\text{Hence, } I_3 = I_1/\left(\frac{R_{3a} + (R_{\text{inst}} + R_{\text{brushes}})}{R_{4b}} + 1\right)$$

$$= I_1 \times R_{4b}/(R_{3a} + R_{\text{inst}} + R_{\text{brushes}} + R_{4b})$$

$$= R_{4b}/(R_{3a} + R_{4b} + R_{\text{inst}} + R_{\text{brushes}})\, I_1$$

but $R_{3a} + R_{4b} =$ constant

and $R_{\text{inst}} + R_{\text{brushes}} =$ constant

Therefore, since $R_{4b} \propto$ pull,

$I_3 = C \times R_{4b}$ (proportional to pull) $\times I_1$ (proportional to speed), which means that the instruments will respond to the speed-pull relationship, and by the use of a constant multiplier will give a correct indication of power.

R_5 is the tapered resistance to which previous reference has been made. Its value is determined by taking several points (uniformly spaced) along R_4 and R_5 and substituting the equation:

$$\frac{[R_{3a} + (R_{\text{inst}} + R_{\text{brushes 3 and 4}})] \times R_{4b}}{[R_{3a} + (R_{\text{inst}} + R_{\text{brushes 3 and 4}})] + R_{4b}} + R_{4a} + R_{\text{brush }5} + R_{5b} = C = R_t$$

$$\text{or } R_{5b} = R_t - \left[R_{4a} + R_{\text{brush}5} + \frac{[R_{3a} + (R_{\text{inst}} + R_{\text{brushes 3 and 4}})] \times R_{4b}}{[R_{3a} + (R_{\text{inst}} + R_{\text{brushes 3 and 4}})] + R_{4b}}\right]$$

The dynamometer has the advantages of compactness, lightness, and flexibility. It can be adapted to almost any size of tractor and load. If subsequent tests prove it to be as satisfactory as preliminary tests seem to indicate, it should be a very useful addition to the list of apparatus of every agency making drawbar studies.

AUTHOR'S NOTE: Acknowledgment is gratefully made to C. E. Barbee for valuable suggestions given in the construction of the dynamometer.

What Industry Expects of Public Research Agencies

By H. W. Gerlach

THE agricultural engineer engaged in research in public institutions provides much of value to agriculture, by providing new and useful information to the farm equipment industry. To provide machinery for an economically sound mechanized agriculture, it is highly important that truly cooperative spirit exist between public institutions and industrial organizations engaged in the manufacture and sale of the product, because it is quite apparent that many of the findings of public research can only find their practical expression and utilization through the efforts of an industrial organization.

Institutional research workers, supported by funds made available to them by legislation, are provided with the opportunity of doing basic research work which may or may not find ultimate practical application. The very nature of their operating budget precludes the necessity of their doing work that will return income sufficient to pay the cost thereof. In this respect they differ from industrial workers who, for the main part, must be paid from earnings resulting from their work.

Considering the epochmaking strides that are being made along the lines of the sound application of machinery to the farm, it is obvious that never before was there a greater need for a truly cooperative spirit between the public service research worker and the industrial research worker. One or two generations ago this need was less apparent than today, as at that time farm machines were more simple and fewer in number. Today the picture has radically changed, with more and more agricultural operations falling under the influence of the tractor, the combined harvester-thresher, the heavy-duty and thoroughworking tillage tools, the forage-conditioning machines, etc.

In principle we might say that it would seem that the job of the research engineer at a public institution might be (1) developing better use of already existing agricultural machines and (2) studying operations now done by laborious or inefficient processes that might be improved upon by modification of old or by development of new mechanization.

It would seem that industry must carry the responsibility of the design of the machine for the efficient accomplishment of the job, toward which the research man from the public institution has pointed the need. The reason for this lies in the fact that industry has more intimate knowledge of the availability of manufacturing processes and the distribution and service facilities that are available once the machine has been developed.

Industry needs the public institution to supply it with the answer as to the requirements that the machine must meet. For example, let us say that a public research engineer has studied the economics of doing a particular agricultural job mechanically. He has compared the operating costs that would result, if the job were mechanized, with those costs existing when the job is done manually. His findings are released to industry, which can make a second careful analysis of how the job is now done, the cost of doing it in its present manner, and the reason for change. Then follows logically the analysis as to likely market for a new machine, if it is made available, and the problems of manufacture, sale, and service of the machine when it is finally placed on the market.

Splendid examples are available pointing out how completely many college research projects have fulfilled these requirements. Such widespread activities as the research on erosion control, particularly terracing, cultural methods for the control of bindweed, basic research along the lines of silo filling, conditioning of forage crops, feed grinding, etc., all fulfill these requirements. Specifically, we might point to the thorough and complete work that was done a few years ago on silo fillers. The findings of that research project demonstrated needed changes in existing design. Industry was quick to recognize these basic findings and modification of the machine followed.

Many of the larger implement manufacturers are in effect agricultural engineering in an applied sense. Their operations are national and oftentimes world-wide. Nevertheless these concerns, because of practical limitations, are prevented from studying some of the less apparent or less defined needs of agriculture in the territories in which their products are sold. The institutional worker, because of his intimate connection and association with localized agricultural needs, is in a splendid position to prepare definite recommendations that will permit the distant manufacturer to proceed on a sound basis, to prepare plans, design, sell, and service the machines to efficiently fill the needs that have been outlined by the local engineer. We can easily see how much better fitted are public institution research workers in the corn belt states for the job of making definite recommendations as to design requirements of machinery for, let us say, the control of the European corn borer. How much better fitted are the research workers in the Great Plains area, for the job of supplying definite recommendations for the requirements of implements used in the control of bindweed.

A note of warning is in order regarding such recommendations as to the need of machines. Occasionally industry is apparently reluctant to follow recommendations. This hesitance should actually be encouraged rather than condemned because, considering their position of trust and responsibility to their customers, it is important that machines made available by them must continue to be serviced and maintained. Too often in the past farmers have found themselves with orphaned machines which, because of the lack of repair parts, become useless and represent a considerable capital investment loss. The fact that most present-day industrial concerns, even in the face of marked technological improvement in machines, still make available at questionable profit, repairs and service for long outmoded machines, is a splendid indorsement of the high degree of responsibility in which industry holds its position.

Presented before the Committee on Research round table at the annual meeting of the American Society of Agricultural Engineers, at Asilomar, Pacific Grove, Calif., June 27, 1938.

Author: Agricultural engineer, Caterpillar Tractor Co., Mem. A.S.A.E.

A splendid field of effort awaits the institutional worker who will study ways to increase the use factor of agricultural machines made available by industry. Agricultural engineers usually agree that the added yearly utilization of the farm tractor has justified its acceptance on smaller farms. Twenty years ago the farm tractor with its utilization held to one or two of the major farm jobs, such as plowing and seedbed disking, was too expensive to compete with animal power on many farms. With tractor utilization increased many-fold, until it today includes plowing, planting, cultivating, harvesting, belt-work, power take-off work, etc., we find the farm tractor not only practical but most profitable for smaller American farms.

The research work that is now going forward on the dynamic properties of soil is being most admirably handled by public agencies. Quite obviously few industries have either the ability or the obligation to carry on this type of work. However, as findings are released, industry may apply some of them to the development of farm machines so that tillage, which is the greatest power-consuming operation on the farm, may be made less costly.

Certainly the agricultural engineer in public service is in a most logical position to connect up research work of an engineering nature with the research work being carried on by the allied agricultural workers in such fields as agronomy, soils, entomology, biochemistry, farm management, and the like. Because of the close daily association between these workers at agricultural colleges, the college agricultural engineer is in a better position to effectively correlate his work with their efforts than is the industrial agricultural engineer. The latter, because of his inability to contact these men often, is often greatly handicapped. For example, we find cases of where cooperative work between the agricultural engineer and the plant breeder has shown that, where redesign of existing machines would be expensive and impractical, it is possible for the plant breeder to bring about desirable changes in the mechanical structure of the plant, so that already existing machines are made satisfactory for the job. The success of the smaller combines in territories where grain ripens unevenly has been largely a result of the development of plant varieties in which grain shattering is held to a minimum, even when certain parts of the field are overripe. In a way we might say that the public service agricultural engineer is in a position to operate somewhat as a liaison officer, developing, correlating, and making available to industry the recommendations of these allied agricultural workers.

Public service engineers have already done much in the standardization of machine design. For example, the work of committees of the American Society of Agricultural Engineers has done much to standardize belt pulley speeds, power take-off design, height of drawbars, etc.

In conclusion, it might be said that in all three of the great major classifications of agricultural engineering, namely, structures, soil and water control, and energy utilization, there is a distinct place for both the agricultural engineer in public service and the agricultural engineer in private industry. The fine degree of cooperation now existing between these two need scarcely be commented upon. Most certainly it would seem that their division, in responsibility to agriculture, lies in the public service research worker directing his greatest effort to the analysis of the need of new machines and the more efficient utilization of machines already existing. His co-worker, the agricultural engineer in industry, may then devote the major part of his time to the design of machines, the improving of already existing machines, and the sales and service problems that are such an intimate part of the business side of mechanized agriculture.

Fundamental Concepts of Air Conditioning

(Continued from page 430)

approaches the wet bulb of the entering air. The cooled air can be considered to consist partly of initial air, and partly of air with a dew point equal to the water temperature, if entrainment of spray droplets is eliminated. Energy can be added to raise the water temperature and give humidification, or it can be removed to lower the water temperature and provide dehumidification.

It will be seen that the finned-surface convector and the air washer can be used to produce the same result in dehumidifying, if the surface and spray temperatures are the same, and if the area and volume are adequate. In case the desired ratio of dehumidification to cooling is large, the low dew point which must be carried will give excessive cooling, and reheating must be used.

The Arizona or desert cooler is similar in action to the spray chamber, but a wet pad instead of a spray is used for air-water contact. The wet-bulb temperature of the exit air is the same as that of the initial air, the temperature is lower, and the humidity is higher. An astounding number of homemade units have been installed in the Southwest in the past three or four years, and a great many commercial units have been sold. This unit gives satisfactory results only in dry climates, where the wet bulb does not go over 75 F. Most users prefer to pack the pad loosely enough to keep the exit air four degrees above the wet bulb, giving a relative humidity of 80 to 83 per cent. In passing through the house, the air temperature rises, the dew point rises, and the relative humidity drops. It is essential to have a fan capacity which will give 20 air changes per hour, which will keep the air temperature rise at 5 to 7 F in the average house. If much more than this rise is permitted, the last room will be less comfortable than if the cooler were not in use.

In addition to methods requiring refrigeration, dehumidification can be accomplished by chemical means, or by adsorption. Adsorption, on silica gel, for example, is however a constant wet-bulb process. The latent heat of condensation of vapor raises the temperature of the air stream. Heat energy is needed to reactivate the drying agent (to drive off the condensed moisture), and, for comfort cooling, the air must be cooled more than if it had not been dehumidified.

In brief, no attempt should be made at comfort cooling without installing insulation. Having insulation, a great deal can be done with night air cooling and with well water in "radiators" in humid climates. In dry climates, the evaporative cooler gives excellent results. Under extreme conditions, refrigeration is necessary to give the temperature recommended for comfort.

Tillage in Relation to Weed Root Systems

By E. A. Hardy

THE LOSS to agriculture due to growing and marketing weeds has amounted to such a figure that, in some areas, lands have been abandoned and considered unprofitable. In Western Canada 2,123,098 tons or 70,732 carloads of dockage has been shipped out of the country from the 1924-25 to the 1936-37 crops, inclusive. The loss in feed value and freight for the thirteen crops totalled $29,733,830. This by no means covers the total loss to western farmers through the needless shipment of dockage. The loss in grain value, due to lower yields, is stupendous. In growing one bushel of dockage it has been estimated that from two to five bushels of grain have been killed out. Also the cost of threshing the weed seeds and hauling them to the elevators is no small figure.

This annual loss due to growing and harvesting weeds is not singular to western Canada. It is only typical of the losses in all agricultural sections in the United States as well.

Growth of weeds and annual dockage has increased each year in spite of the use of the most up-to-date power units and tillage machinery. The increase in weed growth and dockage is largely due to the fact that the tillage machines are designed by engineers to do what is considered a suitable piece of work, without scientific knowledge about weed root systems and requirements for weed eradication. The problem of weed eradication is one for the agricultural engineer and the field husbandman to solve together. The use of tillage machinery can only partly eradicate and control the weed growth. The crops being grown, rotations, and systems of summer fallow all have a definite bearing upon the results. The field crops man must outline in detail the requirements of weed eradication, so that machines can not only be designed correctly but also operated scientifically, for the eradication of weeds.

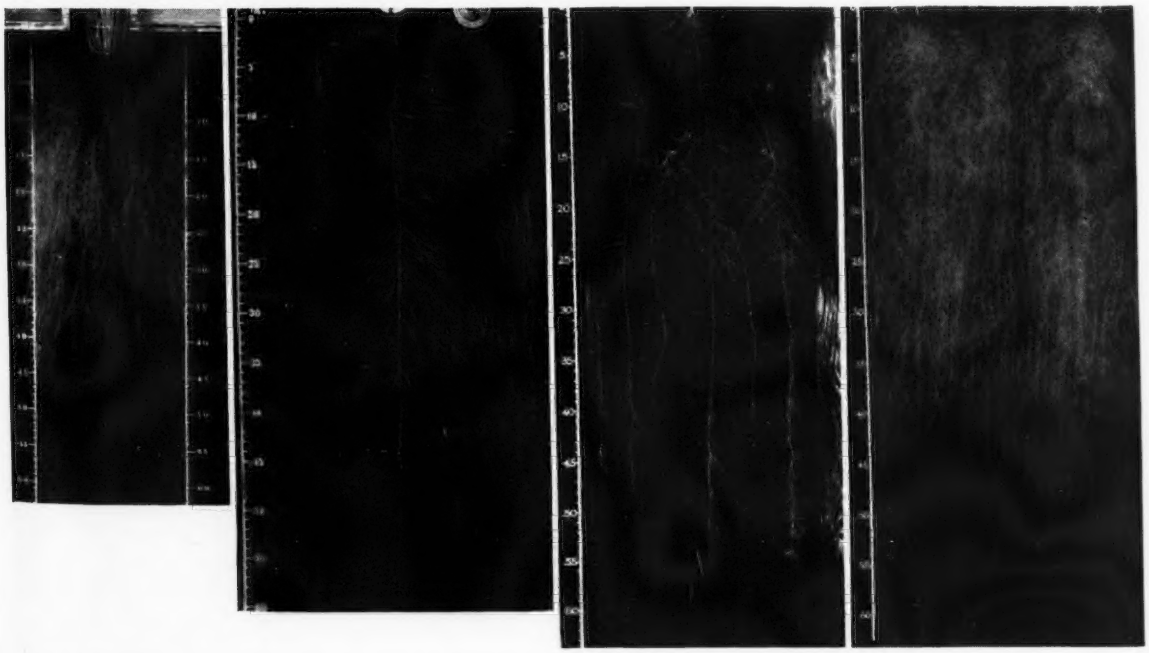
Quackgrass. Quackgrass is a weed which has spread all over the Middle West, in spite of tillage machines and farmers. Special machines have been designed to plow and shake the roots out of the soil and finally place the roots on top of the soil so that they can be dried and removed. Spring-tooth harrows have been used for years to comb out the roots, so that the grass could be exterminated. The results of root removal by any method have been disappointing.

The smothering of quackgrass has long been effective in small patches, but has not been generally used in large areas. The one-way disk has been used for smothering quackgrass roots on the Lockwood Provincial Weed Farm. It was found that a complete kill was made by using the one-way disk to cut the top off the grass, to a depth of ¾ to 1 in below the surface, once each week for from 4 to 8 weeks, depending upon the rainfall. Root systems were left in the sandy soil to prevent soil drifting and were smothered, since no green growth was permitted above the soil.

Wild Oats. Wild oats have been the cause of more low grades in small grain than almost any other weed. Wild

Presented before the Power and Machinery Division at the annual meeting of the American Society of Agricultural Engineers, at Asilomar, Pacific Grove, Calif., June 30, 1938.

Author: Professor and head of the agricultural engineering department, University of Saskatchewan. Mem. A.S.A.E.



(LEFT TO RIGHT) FIG. 1 ROOT SYSTEM OF A WILD-OAT PLANT. FIG. 2 SINGLE ROOT CROWN OF WILD OAT AT MATURITY. FIG. 3 ROOT SYSTEM OF MARQUIS WHEAT. FIG. 4 ROOTMASS OF MARQUIS WHEAT GROWN IN 6-IN DRILL ROWS

TABLE 1. COMPARATIVE STUDY OF A SINGLE PLANT OF WILD OATS AND ONE OF MARQUIS WHEAT, EACH GROWN ALONE IN THE CENTER OF AN AREA 10 FT SQUARE.

(From Project 5, Section E, Tables 8 and 10 Weed Nursery 1934)

Characters studied		Oats data	Wheat data
Top growth			
Height		40 in	34 in
Number of tillers		35	33
Seminal root system			
Number of roots per plant		3	5
Greatest penetration		63 in	63 in
Greatest spread		13 in	16 in
Longest root		65 in	64 in
Shortest root		62 in	55 in
Total length without branches		189 in	300 in
Branches of first order			
Longest branch		37 in	24 in
Number of branches per linear inch		12	15
Frequency of branches at different depths	0 to 10 in	11	15
	10 to 20 in	9	18
	20 to 30 in	8	19
	30 to 40 in	13	18
	40 to 50 in	14	11
	50 to 60 in	17	9
Average length of branches at different depths	0 to 10 in	19 in	14 in
	10 to 20 in	34 in	16 in
	20 to 30 in	28 in	15 in
	30 to 40 in	13 in	12 in
	40 to 50 in	8 in	6 in
	50 to 60 in	1.5 in	2 in
Total number of branches of first order		1,486	4,208
Their total length		20,800 in	37,900 in
Branches of second order			
Longest branch observed		9 in	3 in
Number of branches per linear inch		14	14
Number of branches per seminal root system		121,000	223,000
Their total length		298,000 in	312,000 in
Branches of third order			
(These were very numerous but mostly lost, hence there was not a sufficient amount of material to provide a basis for an accurate estimate.)			
Crown root system			
Number of crown roots		96	73
Greatest penetration		63 in	63 in
Greatest spread		29 in	28 in
Longest root		72 in	69 in
Shortest root		2 in	1.5 in
Their length without branches		2,016 in	1,621 in
Branches of first order			
Longest branch		51 in	36 in
Number of branches per linear inch		14	14
Total number of branches of first order per crown root system		23,000	17,800
Their total length		216,000 in	196,000 in
Branches of second order			
Longest branch observed		13 in	8 in
Number of branches per linear inch		13	13
Number of branches per plant		2,263,000	1,738,000
Their total length		2,859,000 in	2,254,000 in
Branches of third order			
(Branches of third and fourth orders were very numerous but mostly damaged and the estimation was not made.)			
Total length of the entire root system disregarding the root branches of third and higher orders		3,456,005 in	2,802,821 in

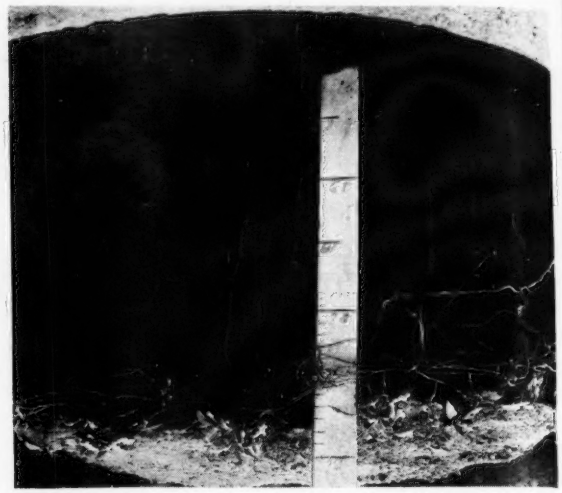


FIG. 5 UNDERGROUND DEVELOPMENT OF PERENNIAL SOW THISTLE

oats have spread throughout North America because of successful competition with crops. The wild oat matures early, so that, for the ordinary crop, the wild oat is mature and shelled off before the harvest.

The weed root system studies conducted by the Dominion government and the University of Saskatchewan have revealed a great many facts about roots, which in part explain the failure to eradicate the weed. For instance, the wild-oat plant was 40 in high and had 35 tillers. There were three seminal roots 62 to 65 in long, penetrating 63 in deep. Table 1, taken from the root studies, helps to indicate the size and extent of the root system of a wild-oat plant, as compared with that of Marquis wheat.

The wild oat study also revealed the fact that when wild oats are disked, cultivated, or cut up generally, the cut sections of the stems scattered over the soil may take root if the moisture and soil covering of the stem is right. It was found that wild oats were scattered rather promiscuously over fields in this way. Plowing wild oats, after sufficient growth has developed to spend the strength of the seed, kills the plant and seed.

Crop Competition. The root systems of Hannchen barley are more like those of the wild oat. The Hannchen

FIG. 6 A PATCH OF POVERTY WEED, DEVELOPED FROM ONE TEST PLANT AT THE CENTER STAKE. INNER AND OUTER CIRCLES OF STAKE INDICATE PROGRESSIVE DEVELOPMENT OF UNDERGROUND RUNNERS, FOLLOWED BY NEW PLANTS

barley is earlier than wheat and is a good crop to smother out weed growth.

Wild mustards developed only at the border of the test plot and were mostly smothered out when grown in competition with Hannchen barley. Wild mustard was luxuriant throughout the entire plot when grown in competition with Marquis wheat.

Crested wheat grass has also been found to offer great competition to perennial weeds. Research in this field indicates the possibility of more increased use of grasses as competitive crops in the control of perennial weeds. Crested wheat grass develops a root system which is very dense and extensive, giving every indication of a type which will smother out less vigorous plants.

A different problem is encountered in the control and eradication of such weeds as perennial sow thistle, Canada thistle, poverty weed, leafy spurge, and field bindweed. These are all creeping-rooted weeds in which the roots are found below the reach of the ordinary tillage implement doing shallow work.

Perennial Sow Thistle. The perennial sow thistle illustrated in Fig. 5 was 428 days from emergence to excavation. It contained 178 in spread of 34 runners, varying from 3 to 18 in deep. Eighteen secondary tap roots had developed, with 36 in penetration.

Canada Thistle. The Canada thistle (Fig. 11) excavated for study was grown from a 4-in runner cutting, developed through three growing seasons. The plant developed a root system which produced 25 shoots, spread over 31 ft 6 in, and penetrated to a depth of 5 ft. The horizontal runners were found from 8 to 12 in deep, considerably below the depth of tillage machinery.

Poverty Weed. Poverty weed is a perennial which is found in heavy clay soils and has not been controlled by the ordinary tillage practices. It has great drought resistance. Its roots are thick and woody, protected by a thick layer of an impervious, corky substance. The test plant developed one bushy plant and seven runners in 1930, seven top shoots and 14.5 runners in 1931, 14 top shoots and 22 runners in 1932, and 22 top shoots and 30 runners in 1933. The final lateral spread of underground runners was 60 ft in diameter in four years, and of top growth, 42 ft in the same time. The average depth of the horizontal runners was from 1 to 2 ft, while the vertical roots penetrated to great depths. One place in Saskatchewan the vertical roots of poverty weed were found 18 to 20 ft under the surface.

The weed root studies have shown that poverty weed offers the greatest difficulty of all perennial weeds, in eradication. The roots can preserve their viability in the ground for four and probably more years. According to the results at Eston, Sask., three years of continuous black summer fallow put the weed under control, without effecting 100 per cent kill.

Leafy Spurge. Leafy spurge is a perennial plant frequently found in the virgin prairie, but more often in places where occasional or permanent disturbance has destroyed the natural vegetation. A rather innocent looking plant above the ground, it possesses an enormous root system under the surface, which makes it both a vigorous

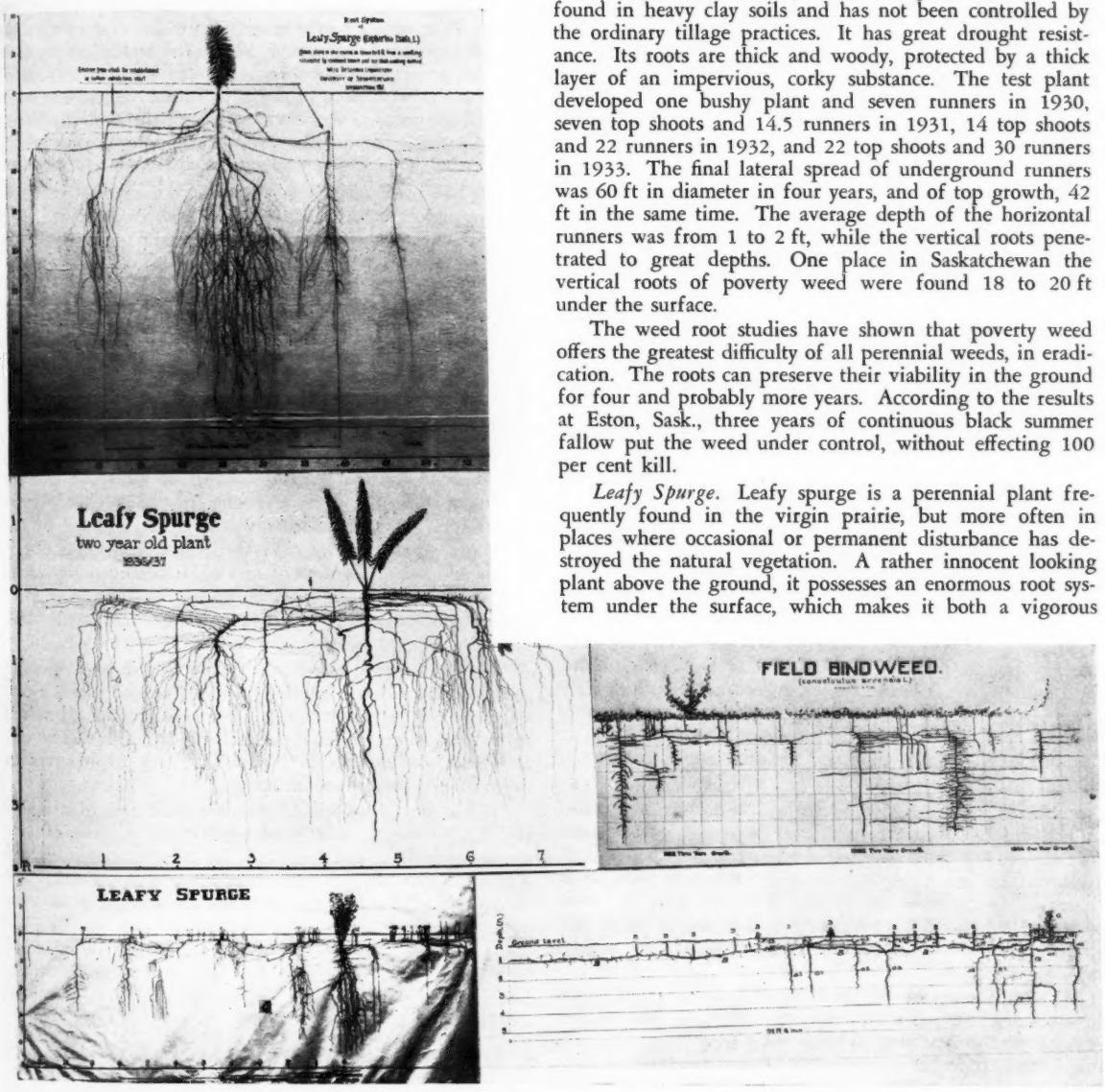


FIG. 7 (UPPER LEFT) LEAFY SPURGE 4 MO OLD. FIG. 8 (CENTER LEFT) LEAFY SPURGE 2 YR OLD. FIG. 9 (LOWER LEFT) LEAFY SPURGE 5 YR OLD. FIG. 10 (UPPER RIGHT) ROOT SYSTEM OF FIELD BINDWEED. FIG. 11 (LOWER RIGHT) ROOT SPREAD OF CANADA THISTLE

competitor to other species, and an almost perpetual occupant of the habitat acquired. Its stem grows from 12 to 18 in tall under the conditions at Saskatoon, and is quite woody and practically branchless at the base. Toward the top it branches freely, produces dense foliage, and abundance of greenish flowers and seed. Physiologically the species is characterized by a milky, bitter cell sap, both in the stem and roots, which makes it highly unpalatable to grazing animals. This is a protective feature of the plant and adds materially to its persistency among other, more useful species easily subjected to overgrazing. The weed was brought to this continent from Europe, apparently more than one hundred years ago, since some specimens were collected as early as 1827. In the United States it occurs from Maine to Washington. In Canada it is most abundant in Manitoba, although reports of its presence in more or less extensive patches east and west of this province are increasing every year, revealing well justified alarm on the part of practical farmers and technical agricultural advisers.

Leafy spurge develops a large root system very rapidly. The lateral spread in 2½ mo varied from 28 to 30 in, in 4 mo 35 to 59 in, in 2 yr 90 in, and in 5 yr 23 ft in length. The 2-yr old plant shows an abundance of new shoots arising from the horizontal runners at the bends in the runners. The vertical roots branch out profusely, even at depths of 2 to 3 ft.

The leafy spurge developed a top growth of 19 in in 5 yr, with tap root penetration of 54 in and 276 in of spread. The laterals were found mostly within the first foot of soil, with laterals, however, producing top shoots from as deep as 6 ft.

Field Bindweed. Field bindweed is not found in many places in Saskatchewan. It is more widely spread through the middle states. It has a root system similar to quackgrass, in that it has great competitive capacity. The weed also develops long climbing vines, which bind cereal crops together and interfere with the operation of harvesting machinery.

The top growth of the weed is much less than the development of the runners under the ground. In 1932, for example, the top shoots occupied an area 6 ft in diameter, while the runners were found in an area of 18 ft diameter. Horizontal runners which produced top shoots were found mostly in the top foot of soil. Great numbers of laterals were found at 2 to 3-ft and 4-ft depths. These, however, only supplied the plant with moisture and nutrients. Approximately every fifth runner was thick and fleshy, and from 3 to 7 ft long. The others were fibrous and from 10 to 30 in long. Field bindweed is a difficult weed to control or eradicate, because of the drought resisting characteristics of the root system, and the difficulty of preventing top growth.

Machines and Control Measures. The control measures which are followed where a crop is grown on the land every year, are necessarily based upon efficient operation of such tillage implements as the plow, one-way disk, disk harrow, drag harrow, rod weeder, field cultivator and various types of row-crop cultivators; also upon the timely application of the implements, and the competition offered by the crop.

The efficiency of the implement has been dependent upon sharpness, scouring, and adjustment, as well as the design of the machine. There is no doubt but that the implements have not generally been operated efficiently, and that the widespread increase in weed growth has been due to that fact. However, the design of the implement in many cases prevented the required quality of work to control weed growth without extra application and greater cost. Analysis of a great deal of tillage indicates that the efficiency of many of the common machines is only from 50 to 80 per cent, even when sharp and in good adjustment. The practice of summer-fallow in western Canada and the semiarid sections of the United States has made it possible to till the land throughout one year in the control of weeds as well as to conserve moisture. Where the summer-fallow method has been followed, the land has been rested every other year or every third year, during which time it has been kept free from weeds.

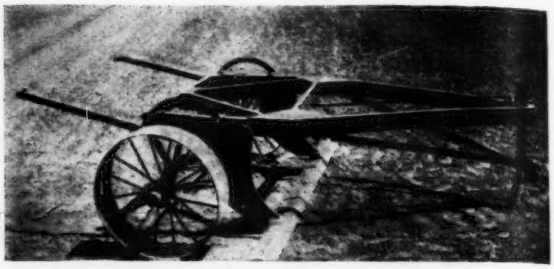


FIG. 12 AN 8-FT, V-BLADE CULTIVATOR DESIGNED TO CUT ALL WEEDS JUST BELOW THE GROUND SURFACE IN ONE OPERATION

It has been considered possible during the summer-fallow period, which extends from one crop to the next crop a year hence, to smother out perennial root systems such as perennial sow thistle, quackgrass, Canada thistle, leafy spurge, and field bindweed. The root systems of all of these weeds are resistant to drought, but must breathe through the tops above the surface. The failure in control of the perennial weeds has been largely due to poor quality work where tillage machines have not cut everything. Sufficient top growth has been missed to permit growth of the roots in spite of the tillage.

Where the eradication of the weed is dependent upon complete and almost perfect cutting of all weed growth on the surface, the disks and cultivators have not proven satisfactory. The rod weeder was designed because of the incomplete work of the cultivator. The field cultivator is a valuable tillage implement to the farmer, if designed so that there is sufficient overlapping of the shovels to provide a complete cut, even when the shovels are partly dull, and also provide clearance for stubble.

The moldboard plow has been altered by removing the moldboards and lengthening the shares to make a cultivator which would produce a complete cut of all weeds in one operation, without pulverizing the soil excessively, and leave the stubble on the surface as a trash cover to assist in preventing soil drifting.

Noble at Nobleford, Alberta, has built a rigid straight-blade cultivator 8 and 10-ft-long, for the purpose of cutting everything in one operation, for more economical weed control. The V-shaped continuous blade 8-ft cultivator has been designed by Murphy at Saskatoon for the same purpose.

It is quite evident that when tillage can be planned with knowledge of plant habits and root systems, much more success will result in the control and eradication of weeds.

AUTHOR'S ACKNOWLEDGMENT: I wish to acknowledge with thanks the valuable assistance rendered by Dr. J. B. Harrington, Mr. T. K. Pavlychenko, and Mr. W. Kossar of the University of Saskatchewan, weed research laboratory in supplying the data on weeds from their 1934 and 1937 reports.

Runoff from Small Drainage Basins

By D. B. Krimgold

THERE IS probably no problem in engineering that is more baffling than the determination of rates and amounts of runoff and of the frequency of their occurrence. Along with other hydrologic phenomena, rates and amounts of runoff must be considered in the rational and economic design of a multitude of engineering undertakings, large and small.

Quantitative data on these phenomena and on their interrelation are needed in determining maximum and minimum stages in streams; maximum, average, and minimum yields of drainage basins; rates and amounts of runoff and stream flow; feasibility of storage and conveyance of water, etc., all of which are the basis for the design of various hydraulic works, including soil and water conservation structures.

Modern scientific methods of investigation of natural phenomena presuppose that some definite laws governing such phenomena exist. Investigations, experimentation, and observations are planned and directed with a view to discovering these laws.

Hydrologic phenomena in general and runoff in particular are extremely complex. The factors affecting runoff are numerous and only a few of them are constant. It is obvious that in attempting to arrive at the laws governing such complex phenomena, the inductive method of reasoning must be employed. This method involves the formulation of a hypothesis and its verification by the study and examination of many individual instances. Many hypotheses based on pure rationalizations were found to be erroneous and were abandoned in the light of results from carefully conducted experiments and measurements. The study of runoff phenomena is probably still in the prehypothesis stage. The important basic factors entering into the problem are only now being fully recognized and defined.

Notwithstanding the large amount of stream-flow data secured through the work of the U. S. Geological Survey and similar agencies throughout the world, it is generally conceded that the existing information on runoff is insufficient for the rational planning and design of hydraulic projects. This is especially true with regard to projects and structures involving runoff from small drainage basins.

In attempting to secure runoff data, priority was naturally given to the type of data required in connection with projects of outstanding economic and social importance, such as domestic, irrigation, and industrial water supply, hydroelectric power, navigation, and flood-control projects. For this reason, with but few exceptions, the gaging stations of the U. S. Geological Survey were established on the major rivers and on their larger tributaries. The need for runoff data from small rural and urbanized areas has long been recognized in connection with the construction and maintenance of highways, railroads, and storm sewers. This need has recently become most urgent in connection with the soil and water conservation work conducted by various state and federal agencies. It will become even more acute in the United States when the Department of Agriculture fully assumes the responsibility placed upon it by Congress in the Omnibus Flood Control and Water Facilities Acts, and when it begins to discharge its obligations to the soil conservation districts as described by D. S. Myer (1)*, in fulfilling these obligations, adequate information for the design of thousands of smaller hydraulic structures will be required. The aggregate cost of these structures will run into millions of dollars. The construction of such structures without adequate information often results in either underdesign entailing costly failures, or in overdesign. In the case of smaller structures, the consequences of overdesign are even more serious than those of underdesign, since good practices are often discarded as uneconomical because they are grossly overdesigned.

Status of Runoff Problem. In order to meet the urgent, immediate need for design data, many attempts were made to develop methods and formulas for estimating runoff from drainage basins on which no records were collected.

A large number of empirical runoff formulas have been developed by engineers in the United States and elsewhere. T. A. Munson (2) lists 36 formulas and four sets of curves that are in standard use in the determination of runoff and

Presented before the Soil and Water Conservation Division at the annual meeting of the American Society of Agricultural Engineers, at Asilomar, Pacific Grove, Calif., June 30, 1938.

Author: Soil conservationist, section of watershed and hydrologic studies, Soil Conservation Service, U. S. Department of Agriculture. Assoc. A.S.A.E.

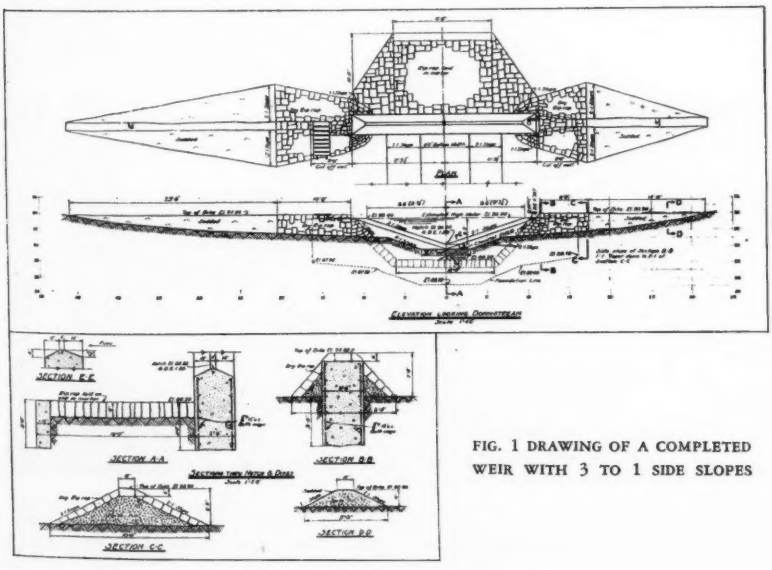


FIG. 1 DRAWING OF A COMPLETED WEIR WITH 3 TO 1 SIDE SLOPES

*Numbers after names of authors and articles refer to the list of references given at the end of this paper.

sizes of drainage structures. He classifies them under four general headings, as follows:

1 Runoff Formulas for Metropolitan Districts and Streams (7 formulas, including Kuichling's $Q = CIA$)
2 Runoff from Small Areas, Swamps, and Wet Lands (6 formulas)
3 Flood Flows from Watersheds Over 200 Square Miles in Area (13 formulas and 2 sets of curves)
4 Formulas and Curves to Determine Bridge and Culvert Sizes (10 formulas and 2 sets of curves).

(Munson's list is by no means complete. Many curves and formulas, including the Ramser curves used extensively in the design of erosion-control structures, were not listed.)

The various methods of estimating floods are discussed by C. S. Jarvis (3) and others under the following headings:

1 Extreme-Flood Formulas
2 Flood-Frequency Formulas
  (a) Formulas with frequency relation implied, involving (1) only drainage area, (2) length or width of drainage basin, (3) rainfall plus other factors, and (4) total flood runoff
  (b) Formulas with frequency relation expressed.
3 Statistical (or Probability) Methods
  (a) Theoretical probability curves
  (b) The duration-curve method
4 Methods Dependent on Relation of Rainfall to Runoff
  (a) "Rational" methods
  (b) The unit-hydrograph method
5 Method for Estimating Peak Flow from 24-hour Average Flow.

An examination of the various formulas and methods reveals that many of them were developed for specific localities and some are further limited with respect to the size of the drainage basins to which they apply. Still others are applicable to runoff and floods of certain frequencies. It is interesting to note that the formulas listed by Munson under "2" and "4" and all but two under "3" contain only one variable, namely, the size of the drainage area in square miles or in acres. All of the formulas listed under "1", except the Kuichling formula ($Q = CIA$), contain the average slope and the maximum intensity of rainfall in inches per hour in addition to the size of the drainage area.

It appears that in developing the various formulas referred to above, the paramount objective was to find some simple device which will give the answer to the troublesome problem and will involve the determination of the simplest factors, such as the area of the drainage basin. All serious students of the runoff problem, including most of the men who are responsible for these formulas, fully realize that they do not truly depict the relationships between the most important factors affecting runoff.

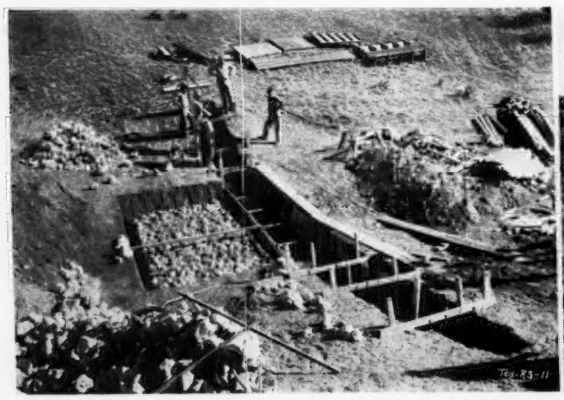
The so-called "rational formula", $Q = CIA$, deserves particular mention. It has come into more or less general use in connection with the design of sewers, erosion-control structures, highway culverts, and other hydraulic structures on comparatively small drainage areas.

On the face of it, this formula is probably less expressive of the factors affecting runoff than some of the others which involve the average slope in addition to the rate of precipitation and size of drainage area. However, this formula, or rather the rational method which it is supposed to express, is probably responsible for a great deal of the recent advance made towards the discovery of the important factors affecting runoff. The discussion of the rational method by Jarvis (3) and others contains the following statement:

> The formula used in connection with this method is one of the most convenient yet devised for showing the relation of rainfall to maximum expected runoff from areas within the range of its proper use, as follows:
>
> $$Q = CIA$$
>
> where Q = maximum runoff, in cfs
> C = the percentage of average rainfall appearing as runoff at the end of the prescribed period at the point of observation
> I = average rainfall intensity prevailing during the period, in inches per hour
> A = drainage area in acres.
>
> This formula is simplified by the coincidence that 1 acre-inch is very closely equivalent to 1 cfs for 1 hour.

C. E. Ramser (4) describes the rational method as follows:

> In the rational method of computing runoff, the various factors influencing runoff are provided for in the formula $Q = CIA$. C, the coefficient of runoff, is the composite effect of all factors, influencing runoff which have been mentioned. I, the rate of rainfall to be provided for, depends upon the intensity for different durations of rainfall for the particular locality, and the duration to be used for any particular watershed is equal to the time of concentration of that watershed. Thus the time of concentration takes care of such influencing factors as the shape and slopes of the watershed and the



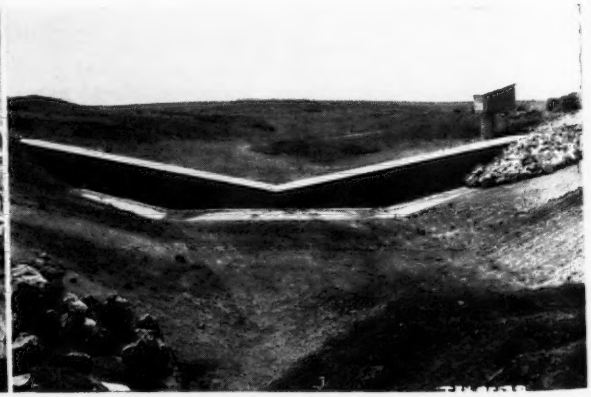


FIG. 2 (LEFT) A 5 TO 1 TRIANGULAR WEIR WITH TRAPEZOIDAL CREST IN THE EARLY STAGE OF CONSTRUCTION ON THE VEGA (TEXAS) PROJECT OF THE SOIL CONSERVATION SERVICE. FIG. 3 (RIGHT) VIEW OF A COMPLETED WEIR (LOOKING UPSTREAM). NOTE THE CONCRETE APRON AND THE PARTIALLY COMPLETED DOWNSTREAM CHANNEL

FIG. 4 CLOSE-UP OF STILLING WELL AND APPURTENANCES AT THE WEIR SHOWN IN FIG. 3

arrangement and character of the drainage channels. To a certain extent, also, it takes account of the vegetation on the watershed, since the distance traveled and the velocity of the water depend partly upon these factors.

In a preceding paragraph of the same paper, he discusses the "apparently unaccountable variations in the runoff coefficients" obtained by him for the various watersheds on the Murchison farm, and states that "there are many interdependent factors entering into the relation between rainfall and runoff, and it is practically impossible to evaluate all of them accurately." He mentions "the effect of previous rains upon the capacity of the ground to absorb water from subsequent rains" and lists a number of factors to be considered. Ramser's discussion of the factors affecting runoff is most valuable because it is based on actual observations.

The runoff data collected by Ramser in 1918 on the Murchison farm and their publication in 1927 were undoubtedly one of the most important contributions toward the discovery of many factors which had not been previously recognized. Since the publication of these data, a limited amount of information on runoff from small drainage areas was collected on the several erosion experiment stations (5, 6, 7, 8, 9) of the Soil Conservation Service. This information is being published and will undoubtedly be fully utilized in the near future. An 11-year record of runoff and rainfall from the Ralston Creek watershed was recently published by the University of Iowa (10). The runoff and precipitation data from the Wagon Wheel Gap (11), the Great Basin (12), and from other studies on small drainage basins in the United States and abroad have not yet been fully utilized in the design of hydraulic structures on small drainage basins.

Although the various studies conducted thus far were more or less fragmentary, they were sufficient to set the students of runoff phenomena on the right track toward the discovery of the factors affecting runoff. Metcalf and Eddy (13) devote considerable space to the discussion of the rational method, which they consider the best available for the determination of runoff in connection with the design of storm sewers. They consider the coefficient of runoff, C, to be a composite of four factors which may be called the coefficients of imperviousness, of distribution of rainfall, of retention, and of retardation. The time of concentration entering into the determination of the rate of rainfall in the rational formula is defined in this book as the "period of time required to establish runoff and for the water to flow from the most distant point (measured in time) to the point under consideration."

These discussions of the "runoff coefficient" and the definition of the "time of concentration" show rather clearly how complex and indeterminate the so-called rational method really is.

M. M. Bernard (14) lists eighteen of the most important factors "entering into the analysis of flood flow on any particular watershed." He classifies six of them as permanent and twelve as variable.

It appears from the foregoing discussion that, although the rational method was instrumental in bringing about a clearer understanding of the factors entering into the problem of determining runoff, it is far from being the solution of this problem. In the hands of unqualified users, the rational method becomes a rather dangerous and misleading device.

The evaluation of the numerous factors which must be considered in arriving at the proper runoff coefficient, time of concentration and rate of rainfall is so involved that only the best qualified hydrologists can and should venture to estimate them. The only determinate factor in the rational formula is the drainage area in acres which can be readily measured.

One of the great shortcomings of the rational formula is that, in using it, it is generally assumed that the maximum runoff will occur when the maximum average precipitation rate for the selected interval of time takes place. In other words, the ordinary user of this formula assumes that the frequency of precipitation is also the frequency of runoff, which is, of course, not necessarily true. The subject of frequency of runoff from small drainage basins is important enough in the design of hydraulic structures to be treated in a separate paper and will not be further discussed at this time.

E. P. Arneson (15), in one of the most interesting discussions of the rational method, points out the difficulty of estimating "the time required for storm water to flow over the surface of the ground to its entry into a channel", and states that "this time is often the larger part of the entire time of concentration for the watershed." It would seem that, in view of the many uncertainties, the safest way to use this method would be in accordance with the following procedure suggested by C. E. Ramser (4):

> In determining the probable rate of runoff from any particular watershed, the rational method should be employed. Values of C, I, and A should be determined for substitution in the equation $Q = CIA$. A, the watershed in acres, should be determined from a map if available, or from a survey of the watershed. C, the runoff coefficient, should be selected from the experimental values for C given in Tables 2 to 7, such revisions being made as seem necessary to account for differences in characteristics. I, the rate of rainfall in cubic feet per second per acre—for practical purposes this is the rate of rainfall in inches per hour—depends upon the time of concentration for the watershed, and upon the frequency period decided upon. The time of concentration can be determined approximately by measuring the distance and estimating the average velocity from the most remote point to the outlet of the watershed, by channel.

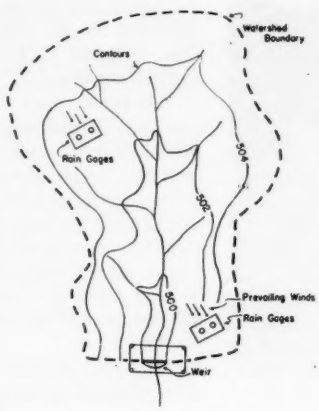
In view of the uncertainties involved in the determination of the "time of concentration", the above precedure would be even safer and more adequate if it specified that the time of concentration be determined in the same manner as the "runoff coefficient."

As more data on runoff from watersheds of various characteristics become available, the task of estimating runoff will become increasingly simplified. At the same time, the increased amount of information will form the basis for a more satisfactory solution of the runoff problem. Already a noteworthy attempt has been made to enumerate the basic factors which must be known in order to solve the runoff problem and through it many other hydrologic phenomena.

R. E. Horton (16) refers to the infiltration theory of surface runoff. Under "Relation of Surface Runoff Phenomena to the Controlling Variables" he states:

> Considering direct surface runoff alone, as distinguished from the channel phase of runoff, and excluding ground-water flow, it is evident from the preceding that all the phenomena of surface runoff are governed by the following independent variables: (1) Rain intensity and its distribution, (2) the duration of different phases of the rain intensity graph, (3) infiltration capacity (f), (4) depression storage (Vd), (5) surface slope (S), (6) length of overland flow (lo), (7) roughness of the surface (n), and (8) character of overland flow, whether turbulent, mixed, laminar, or subdivided by grass, etc. This governs the value of the exponent M in the overland flow equation.

It is too early to say whether the infiltration theory of surface runoff will give the answer to the runoff problem, and, if so, whether it will afford a means for the solution of specific practical problems. With a few assumptions, which he himself feels should be verified by factual data, Horton was able to offer what is, in effect, a reasonable hypothesis. Whether it will stand the test of verification by carefully planned experiments and observations is yet to be proved.



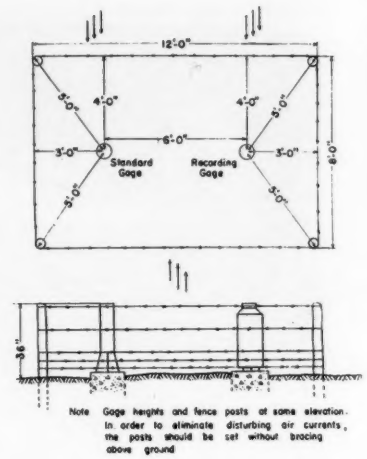
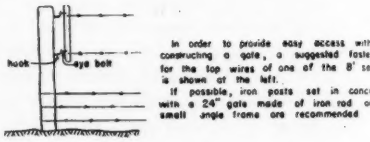


FIG. 5 (ABOVE) TYPICAL INSTALLATION OF RAINFALL MEASURING STATIONS ON DRAINAGE BASINS OF 30 TO 200 ACRES. FIG. 6 (RIGHT) PLAN AND ELEVATION OF ENCLOSURE FOR RAINFALL MEASURING STATION


hook
eye bolt
In order to provide easy access without constructing a gate, a suggested fastening for the top wires of one of the 8' sections is shown at the left.
If possible, iron posts set in concrete, with a 24" gate made of iron rod or small angle frame are recommended

He was, however, able to arrive at the several basic independent variables and to suggest the functional relationship between these variables. It will still be necessary to determine the numerical coefficients to make this functional relationship useful in the solution of practical problems. These coefficients, however, are numerical values which are not themselves functions of a large number of variables as are the so-called "coefficient" of runoff in the rational formula or the "time of concentration."

In order that Horton's infiltration theory may be adequately tested and the necessary numerical coefficients obtained, it is necessary to secure a large number of runoff hydrographs and records of rainfall such as are obtainable from runoff and precipitation measuring stations equipped with suitable recording instruments. Together with these records, accurate information on the characteristics of the watersheds must also be secured. But isn't this also the type of information required to meet the immediate needs for runoff data in connection with the extensive program of soil and water conservation, flood control, and water utilization?

RUNOFF STUDIES CONDUCTED BY THE SOIL CONSERVATION SERVICE

Adequate data on runoff from small drainage areas are indispensable in the development and application of suitable methods for soil and water conservation, proper water utilization, and the control of floods on upstream tributaries of larger rivers. This was fully recognized by the Soil Conservation Service from the very inception of its work. The engineers of the Service were faced with the task of designing terraces, channels, check dams, impounding dams, spillways, and other hydraulic structures throughout the United States. Except for the limited data from the Murchison farm studies and the Ramser curves (7) which were based largely on these data, there was practically nothing to go by in designing such structures. The Service as a whole was also in need of quantitative data on the effects of soil and water conservation practices on runoff, erosion, and floods.

It was in order to secure this information that the Section of Watershed and Hydrologic Studies of the Division of Research was established soon after the Soil Conservation Service was made a permanent agency by Act of Congress in April 1935.

In November 1935, the general working plan for experimental watershed studies in the North Appalachian Region (18) was prepared by the Section of Watershed and Hydrologic Studies. The objectives of the studies were stated as follows:

1 To determine the effect of land use and erosion control practices upon the conservation of water for crops and water supply and upon the control of floods under conditions prevailing in the North Appalachian region of the United States.

2 To determine the effect under "1" for small and large areas and to trace variations in this effect from the smallest plot and lysimeters through a series of intermediate watersheds to the largest watershed on the project.

3 To determine the rates and amounts of runoff for precipitation of different amounts and intensities for watersheds typical of the North Appalachian region of different configuration, size, shape, topography, cover, underground conditions, land use and erosion control practices. To furnish data needed for use in the design of erosion control structures and in the design and operation of the Muskingum Watershed Conservancy District and other flood control projects lying within the North Appalachian region.

It should be noted that one of the major objectives of the experimental watersheds was to secure runoff data needed in the design of hydraulic structures.

The studies on these experimental watersheds are to continue for a long period of time in order that the effects of land use and soil and water conservation practices can be properly determined. The work, however, was originally planned so that runoff data for use in design would become available in the early stages of the studies.

The establishment of the North Appalachian and the Texas Experimental watersheds is practically completed and

FIG. 7 VIEW OF A RAINFALL MEASURING STATION ON A 23.6-ACRE DRAINAGE BASIN ON THE VEGA (TEXAS) PROJECT OF THE SOIL CONSERVATION SERVICE

records from them are being obtained. The establishment of the Great Plains watershed near Hastings, Nebr., has recently begun. Several papers describing the various phases of the work on these experimental watersheds were published in AGRICULTURAL ENGINEERING, "Soil Conservation", and in other technical journals. Ramser (19) gives a complete description of the experimental watershed studies.

By the fall of 1936, it became apparent that in order to secure the urgently needed runoff data for the various parts of the country, runoff studies on the various demonstration projects scattered throughout the United States would have to be resorted to in addition to the experimental watershed studies. This, together with an urgent request for information by the Engineering Section of the Service, resulted in the inauguration of the runoff studies on 21 projects in the 11 regions of the Soil Conservation Service by the Divisions of Operations and Research of the Service.

The procedure followed in the selection and establishment of these studies, the instrumentation and methods used to secure the data, the proposed method of compilation and dissemination of the data, and the organization and present status of the work are briefly described in the concluding part of this paper.

The type of runoff data needed in the various regions of the Service in connection with the design of soil and water conservation structures and practices are determined jointly by a representative of the Section of Watershed and Hydrologic Studies and the regional technicians (engineers, soil scientists, and agronomists).

After the type of runoff data most urgently needed in the "runoff problem areas" in a given region is determined, the projects that are most representative of the runoff problem areas are designated for such studies. From three to six typical drainage areas are selected on each of these projects. Preliminary topographic, soil, and cover maps of the selected areas, as well as plans, profiles, and cross sections of the proposed sites for the runoff measuring stations, together with a complete description of the areas and of the cropping plans, are prepared. With this information, the necessary approvals are secured and the runoff and precipitation measuring stations are designed by the Section of Watershed and Hydrologic Studies of the Division of Research. The facilities and personnel of the project are utilized in constructing the installations and in making the necessary surveys and observations.

In order to attain the objective of the runoff studies, the information secured must include (1) adequate runoff hydrographs; (2) complete records of amounts, rates, distribution, and time of occurrence of precipitation; (3) accurate information on the permanent characteristics of the drainage basins, and (4) sufficient data on the conditions of the soil and vegetative cover at the time runoff occurs.

A set of detailed instructions and outlines of procedure covering all the phases of the work are now being prepared. Little or no precedent exists for many phases of the work. The various instructions and outlines of procedure are undergoing constant revision in the light of the experience gained during the construction period and during the first season of operation. Many improvements in the instrumentation have been made since the earlier runoff studies were undertaken, yet a great deal still remains to be done. The same is true with respect to methods of compilation and analyses of the data. No attempt will, therefore, be made to give more than a very brief and general description of the instrumentation and methods to be used in these studies.

Runoff Hydrographs. The storm runoff from small drainage basins is of very short duration. The fluctuations in stage are very rapid and the critical peak flows persist for only a few minutes. It is extremely difficult and often impossible to secure adequate runoff hydrographs from such drainage basins by means of current meter measurements.

Some automatic runoff measuring device must therefore be used. Such a device to be suitable for the various conditions encountered must meet the following requirements.

1 It must have a *definite, continuous, and stable* stage-discharge relationship for both rising and falling stages which can be established without recourse to current meter measurements.

FIG. 8 THE LOCATION OF THE RUNOFF STUDIES ON DEMONSTRATION PROJECTS OF THE U. S. SOIL CONSERVATION SERVICE AND THE NUMBER OF DRAINAGE BASINS UNDER INVESTIGATION ON EACH PROJECT, AS WELL AS THE LOCATIONS OF THE EXPERIMENTAL WATERSHEDS

TABLE I

RUN-OFF STUDIES ON THE DEMONSTRATION PROJECTS OF THE SOIL CONSERVATION SERVICE
CHARACTERISTICS OF DRAINAGE AREAS AND STATUS OF CONSTRUCTION

April 25, 1938.

(Note: * = Completed installations to date (April 25, 1938) ** = Pasture, Meadow or Range
oo Columbus Open Control, Current Meter Rating ooo = Compound Weir

No.	Location: SCS Region	State	Town	Farm Name	Gaging Station No.	Area In Acres	Number Rainfall Stations	Slope: Range	Slope: Aver.	Vegetal Cover (% area): Timber	Grass	Cultivated	Soil Type: Series	Soil Type: Texture	Rectangular Weir: Side Slopes	Rectangular Weir: Bed Width	Rectangular Weir: Top Width	Rectangular Weir: Capacity (cfs): c.f.s.	Rectangular Weir: Capacity (cfs): in/hr	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
1*	1	N. Y.	Bath	Bettner Creek	M-I	2000.0	12	0-50	15	11	43	36	Glacial Origin	Mostly well-drained	oo Comb	6.0	50.0	3000	1.5	Control to be changed
2*	"	"	"	Conrig	C-II	12.5	1	0-25	10	0	40	60	Bath	Deep sandy loam	2:1	2.6	10.4	98	4.6	Strip cropped
3*	"	"	"	Coye	M-III	24.0	2	0-30	15	0	45	55	Lordstown & Wardin	Shallow loam	2:1	3.3	13.2	100	4.2	"
4*	"	"	"	Edmonds	M-IV	62.5	1	0-20	10	2	30	68	Trumbull	Shallow clay loam	ooo 2:1 5:1	2.5	21.0	65	3.1	Terraced
5*	"	N. J.	Freehold	Burnett	M-I	21.0	1	0-15	8	0	5	95	Collington	Loam & sandy loam	ooo 3:1 5:1	2.5	21.0	65	3.1	"
6*	"	"	"	Keith	M-II	30.0	2	1-10	5	0	20	80	Colts Neck	" " "	2:1	1.0	12.0	60	2.7	
7*	"	"	"	Duval	M-III	70.0	2	1-20	5	0	50	50	Collington	Sandy loam	2:1	4.1	16.4	175	2.5	
8*	"	"	"	Ward	M-IV	100.0	2	1-10	5	0	30	70	"	"	5:1	3.5	13.0	250	2.5	
9*	"	Md.	Hagerstown	Reador	M-I	54.0	2	0-25	8	0	40	30	Frankstown & Hagerstown	Silt loam	3:1	3.4	20.4	175	3.2	
10	"	"	"	Phein	M-II	79.0	2	Information not yet available												
11*	"	"	"	Bohrer	M-III	140.0	2	3-30	10	7	33	60	Porters	Gravelly loam	oo 5:1 10:1	2.3	39.0	140	3.5	
12	"	"	"		M-IV			Drainage area not yet selected												
13	"	Ga.	America	Battle, R.A.	M-I	24.0	1	0-7	3	0	25	75	Norfolk & Norton	Sandy loam	3:1	3.0	18.0	120	5.0	Terraced
14	"	"	"	Battle, Mrs. A.	M-II	35.0	2	0-7	3	20	20	60	Mostly Norton	" "	2:1	3.7	16.8	140	4.0	"
15	"	"	"	" "	M-III	30.0	1	3-7	5	0	0	100	Norton	Loamy sand	2:1	3.8	15.8	130	5.0	Terraced
16	"	"	Norris		M-IV	52.0	2	0-3	2	0	0	100	Red Bay	Sandy loam	2:1	3.1	17.6	212	4.0	"
17	"	Va.	Chatham	Staley	M-I	12.6	1	3-20	7	0	80	20	Madison	Fine sandy loam	2:1	2.1	12.4	85	6.75	Terraced
18	"	"	"	Bryant	M-II	27.0	1	3-12	7	0	0	100	Cranville	Sandy loam	Measuring weir not yet designed					
19	"	"	"	Rogers	M-III	13.0	1	3-7	5	0	30	70	Appling & Durham	Sandy loam						
20	2	Ohio	Hamilton	Plake	M-I	193.0	3	0-25	5	10	20	70	Russell & Pleasantie	Silt loam	5:1	4.9	49.0	600	3.5	
21	"	"	"	Dana	M-II	17.6	1	3-25	10	0	100	0	Russell	" "	2:1	3.0	12.0	80	4.5	
22	"	"	"	Tecumseh	M-III	28.0	1	0-8	5	0	100	0	Russell & Pleasantie	" "	2:1	3.7	14.8	135	4.7	Terraced
23	"	"	"	Schmidt	M-IV	13.6	1	3-12	8	0	35	65	" "	" "	3:1	2.7	16.2	90	5.7	"
24	4	Texas	Garland	Guthrie	M-I	22.0	1	0.5-2.5	1	0	50	70	Bell	Clay	3:1	3.0	18.0	120	5.8	Terraced
25	"	"	"	White	M-II	94.0	2	1-4	2	0	10	90	Bell & Houston	"	5:1	4.5	45.0	564	4.0	"
26	"	"	"	Oates	M-III	10.5	1	2-6	3.5	0	90	10	Houston	Black clay	3:1	2.5	15.0	72	7.0	"
27	"	Ark.	Fontenville	Sears	M-I	12.0	1	0-5	3	0	0	100	Carter, Conterton, Nantucala	Silt loam, gravelly silt loam	2:1	3.0	12.0	86	7.2	Project not yet approved
28	"	"	"	Henderson	M-II	34.0	1	0-15	8	0	100	0	Conterton	Gravelly & stony silt loam	2:1	3.0	12.0	86	7.2	" " " "
29	"	"	"	"	M-III	17.0	1	0-5	3	0	100	0	Conterton, Carter	Silt loam, gravelly silt loam	2:1	3.0	12.0	86	5.1	" " " "
30	"	"	"	Blair	M-IV	22.0	1	2-12	8	100	0	0	Clarksville, Carter	Gravelly silt loam	2:1	3.1	12.4	110	5.0	" " " "
31*	5	Ill.	Edwardsville	Lore	M-I	28.0	1	0-10	8	0	100	100	Alma & Negrito	Silt loam	2:1	3.5	14.0	120	4.3	
32*	"	"	"	"	M-II	50.4	2	0-30	15	0	54	46	Alma, Negrito & Rico	" "	3:1	3.7	22.2	205	4.1	
33*	"	"	Bushton	"	M-III	13.2	1	1-15	5	0	50	50	Alma & Negrito	" "	2:1	3.3	10.4	90	3.9	Terraced
34*	"	"	Lore	"	M-IV	282.0	7	0-50	10	10	40	50	Alma, Secota & Rico	" "	5:1	4.6	46.0	590	2.1	
35	"	Wis.	Pecatonica	Norton	M-I	320.0	9	3-15	8	0	15	85	Tama, Dubuque & Clinton	" "	5:1	5.25	52.5	800	2.5	
36	"	"	"	Bechtl	M-II	57.5	1	3-12	7	0	15	85	Tama & Dubuque	" "	Not yet designed, another area may be substituted					
37	"	"	"	Norton	M-III	54.0	2	3-15	10	0	15	85	Tama & Dubuque	" "	5:1	3.75	22.5	212	3.9	
38	"	"	"	Norton	M-IV	170.0	4	3-15	8	0	15	85	Dubuque & Clinton	" "	5:1	4.6	46.0	590	1.5	
39*	6	Texas	Vega	Reese	M-I	142.0	2	0-3	1.5	0	35	65	Pullman, Spur & Potter	Silty clay & clay loam	5:1	4.6	46.0	590	4.1	
40*	"	"	"	Landergin	M-II	112.1	2	0-3	1.5	0	100	0	" " " "	" " " "	5:1	4.1	41.0	460	3.9	
41*	"	"	"	Langham	M-III	23.6	2	8-50	25	0	100	0	Rough broken land	Gravelly & colluvial loamy sand	3:1	3.2	19.2	130	5.5	
42	"	Colo.	Colo. Spgs.	Pulsco	M-I	10.2	1	1-8	4	0	0	100	Sandy loam top soil, clay loam subsoil		2:1	2.6	10.4	77	5.6	
43	"	"	"	"	M-II	14.2	2	1-10	5	0	100	0	Derived from Dawson sandstone, friable loamy sand		3:1	3.7	22.2	205	5.0	
44	"	"	"	Blaney	M-III	32.5	1	2-8	6	0	100	0	Sandy loam top soil, clay loam subsoil		3:1	3.4	20.4	165	5.0	
45	"	"	"	Ayer	M-IV	36.2	2			0	100	0	Gravelly sandy loam, light-textured subsoil		3:1	3.5	21.0	190	5.3	
46*	7	Ohio	Muskogee	Norris Estate	M-I	91.0	2	3-11	5	0	0	100	Sporkill, Bates	Fine sandy loam	5:1	4.1	41	460	4.9	Level terrace
47	"	"	"	Stone	M-II	47.0	2	2-11	6	0	0	100	Parsons, Bates	" "	5:1	4.1	37	460	5.0	Terraced
48	"	"	"	Reed	M-III	26.0	1	3-7	5	0	0	100	Sporkill, Bates	Fine sandy, sandy clay loams	5:1	3.1	18.6	132	5.1	Other areas may be substituted
49	"	"	"	Trumbo	M-IV	25.0	1	1-15	10	0	100	0	Bates	Fine sandy & stony loam	5:1	3.0	18	118	4.75	for M-I and M-II
50	8	Ariz.	Safford	Public Domain	M-I	520.0	3	0-25	15	0	100	0	Basalt Origin	Stone & gravel & th clay	5:1	5.9	50.0	720	1.4	
51	"	"	"	"	M-II	1050.0	2	0-25	10	0	100	0	"	Stony, gravelly sandy loam	Not yet designed					
52	"	"	"	"	M-III	980.0	2	5-25	20	0	100	0	Granite Origin	" " " "	" "					
53	"	"	"	Public Domain	M-IV	780.0	2	0-10	5	0	100	0	Calcareous	Gravelly & sandy loam						
54	"	"	"	State (Leased)	M-I	750.0	5	10-25	15	0	100	0	Granite Origin	Stony & sandy loam	5:1	5	50	730	1.0	
55	"	"	"	"	M-II	500.0	4	5-25	12	0	100	0	Calcareous	Gravelly & sandy loam	5:1	4.6	46	590	1.2	
56	"	N. M.	Berlson Sp.	Parshall Wash	M-I	307.0		5-50	30	0	100	0		Exposed rock silty bottom lands	Not yet designed, drainage areas will be reduced					
57	"	"	"	Norcross Wash	M-II	1700.0		0-50	24	0	100	0		Clay bed lands	" " " " " "					
58	"	"	"	Deer Springs	M-III	3025.0		0-50	16	0	100	0		Broken rock silty bottom lands	" " " " " "					
59	"	"	"	Muddy Creek	M-IV	5760.0		0-50	20	0	100	0		Bad lands	" " " " " "					
60	"	N. M.	Albuquerque	Cabo Bel Rio	M-I	140.0		2-20	5	0	100	0	Basalt Tertiary Flows		Project approved, designs not completed yet					
61	"	"	"	"	M-II	770.0		2-10	10	0	100	0	"	"	" "	"	"	"	"	
62	"	"	"	"	M-III	62.0		5-50	20	100	0	0	Santa Fe Formation sand, gravels & clay		" "	"	"	"	"	
63	"	"	"	B. Montano	M-IV	200.0		2-100	25	50	50	0	Wemos and bluffs		" "	"	"	"	"	
64	"	"	"	"	M-V	14.0		5-30	20	0	100	0	Soft sandy shales Nacas Verde formation		" "	"	"	"	"	
65	"	"	"	"	M-VI	186.0		5-30	15	0	100	0	" "	" "	" "	"	"	"	"	
66	9	Mont.	Culbertson	Jensen	M-I	700.0		(Project not approved yet, detailed information not available)												
67	"	"	"	"	M-II	1500.0		"	"	"	"	"	"	"						
68	"	"	"	"	M-III	1200.0		"	"	"	"	"	"	"						
69	"	"	"	--	M-IV	48.0		"	"	"	"	"	"	"						
70	10	Calif.	Santa Paula	Felerino	M-I	350.0	4	25-60	30	0	85	15	Altamont	Loam and clay loam	2:1	7.5	30.0	800	2.3	
71	"	"	"	Genovesio	M-II	150.0	2	25-60	30	0	80	20	"	Stony loam	2:1	5.5	22.0	370	2.0	
72	"	"	"	Lagunerias	M-III	42.0	2	1-60	18	0	0	100	Altamont & Lodgewood	Loam	2:1	3.6	14.4	130	3.0	
73	"	"	"	Genovesio	M-IV	43.2	2	1-60	25	0	0	100	Altamont Sherimore	Loam	2:1	3.6	14.4	130	3.0	
74	"	"	"	Davis	M-V	90.5	2	11-25	15	0	0	100	Altamont	Sandy loam, clay loam	3:1	4.0	24.0	250	2.8	
75	"	"	Watsonville	Travero	M-I	14.5	1	10-25	15	0	0	100	Tierra & Montezuma	Silty clay, clay loam & loam	2:1	3.0	12.0	88	6.0	Orchard
76	"	"	"	Tomlich	M-II	18.3	1	10-40	20	0	20	80	Mare Cojo	Deep sandy loam	Not yet designed					Orchard
77	"	"	"	Ellis	M-III	78.8	2	10-25	12	0	0	100	Elkhorn	Sandy loam	" "					To be terraced
78	"	"	"	Nielon	M-IV	32.3	2	1-40	30	0	100	0	McClosky Tierra	Clay loam	" "					
79	11	Ore.	Forberg	Grosso	M-I	17.5	1	3-15	10	0	0	100	Clymple	"	2:1	2.2	8.8	37	2.7	Walnut orchard with cover crops
80	"	"	"	Nelson	M-II	27.7	1	20-40	30	100	0	0	Melbourne	Loam	2:1	1.8	7.2	25	1.8	
81	"	"	"	Frankhauser	M-III	13.0	1	5-18	12	0	0	100	"	"	2:1	2.2	8.8	37	2.8	Terraced orchard
82	"	"	"	Lyons	M-IV	7.0	1	3-15	10	0	0	100	"	"	2:1	1.65	6.6	18	2.6	Orchard with or without cover crop
83	"	Idaho	Emmett	Gardner	M-I	340.0	3	15-30	20	0	100	0	Basaltic	Rocky	2:1	4.5	18.0	225	0.9	
84	"	"	"	Beckman	M-II	70.0	2	20-35	25	0	92	8	Granitic	--	2:1	3.6	14.4	130	1.86	

2 It must fit the topography of the selected site as closely as possible so as to create a minimum of temporary pondage and a negligible volume of permanent pondage.

3 It must be possible of rating in a hydraulic laboratory.

4 Its rating must not be seriously affected by submergence.

5 It must not seriously interfere with farming operations.

6 It must be self-cleaning.

7 It must be durable and simple to construct.

8 The tolerance in its dimensions and form must not be too narrow.

9 It must be inexpensive to build and to maintain.

10 The measuring station, together with all of its appurtenances, must occupy as little space as possible.

After considering all available measuring devices, including weirs and flumes, it was found that a triangular, broad-crested weir would be most suitable to meet the above requirements. Preliminary investigations were conducted at the National Hydraulic Laboratory on small-scale models in order to develop the simplest possible weir crest suitable for the purpose. These investigations resulted in the crest shown in Fig. 1. Triangular weirs with this crest and side slopes of 2 (horizontal) to 1 (vertical), 3 to 1, and 5 to 1 are employed. Fig. 1 represents a sample drawing of a weir with 3 to 1 side slopes. The small scale tests indicate that such weirs will satisfactorily meet the requirements outlined above and will function properly under a wide range of field conditions. Calibration curves for the weirs thus far constructed are now being developed at the Cornell University hydraulic laboratory through tests of large-scale models and full size structures under simulated field conditions. Tests are also being made with a view to reducing the width of the crest from 30 to 16 in. The cost of future weirs will be reduced materially if the results of these tests prove satisfactory.

The head over the weirs is measured by means of water level recorders capable of recording unlimited range in stage on a scale of 5 in of chart = 1 ft of stage. Weekly, daily, 12-hr and 6-hr time scales are obtainable by changing gears and pinions of the 8-day recorder clock. The 6-hr chart gives a time scale of 1 in = 25 min. This time scale is being used on practically all of the installations. The water level recorder is housed in an instrument shelter surmounting a stilling well which consists of a corrugated culvert. A float rest ring, a ladder, one or more intake pipes, equipped in some cases with a valve and flush tank, constitute the appurtenances of the stilling well. The intake pipes are placed 10 ft upstream from the center of the 4-in surface of the weir crest. Outside staff gages are used to check the elevation of the water in the stilling well. Fig. 2 shows one of the weirs under construction. Views of a completed installation are shown in Figs. 3 and 4.

The recording pen actuated by the float traverses a line on the chart mounted on the vertical clock cylinder. This line represents the change in head over the weir with respect to time. With calibration curves (corrected for stor-

age) available for every weir, the stage as indicated by the recorder chart is converted into discharge, and the runoff hydrograph for a given storm is plotted.

Precipitation Records. One or more rainfall measuring stations are established in each drainage basin. Each station consists of a recording rain gage of the Fergusson type and a U. S. Weather Bureau standard gage, the latter being used to check the total catch and the operation of the recording gage mechanism. The stations are located so as not to interfere with farming operations, and are exposed as nearly as possible in accordance with the recommendations of the subcommittee on standards of the National Resources Committee. Two types of Fergusson rain gages are used, one with a recording capacity of 6 in and a chart scale of 1 in = 1 in of rainfall, and the other with a recording capacity of 9 in and a chart scale of 1 in = 1½ in of rainfall. Both types are equipped with 8-day clocks and either weekly, daily, 12-hr, or 6-hr charts.

The 12-hr charts giving a time scale of about 1 in = 1 hr is employed on all rainfall measuring stations. Other scales may be used if experience gained in the course of the first season should indicate the advisability of doing so. The record on the chart represents a mass curve of the total rainfall collected in the gage. The slope of the tangent at any point on this curve represents the intensity of rainfall. This curve also shows the time of beginning and end of rainfall and its distribution with respect to time. Standard drawings of rainfall measuring stations are shown in Figs. 5 and 6. A view of a completed installation is shown in Fig. 7.

Where the precipitation occurs in the form of snow, it is necessary to determine the amount of snow accumulated on the drainage area and its water equivalent. On large drainage basins, snow courses are employed for this purpose. A simpler and more accurate method is being developed for these runoff studies. It involves the use of a sufficient number of "snow scales", consisting of graduated stakes properly distributed over the drainage basin. Readings of depth of snow are obtained from the "snow scales" by means of a transit or a pair of binoculars and are plotted on a map. The water equivalent is determined by means of samples taken at a number of carefully selected locations.

The total amount of snow and its water equivalent for the various portions of the drainage basin are determined from the map and the samples. The number of such determinations during the winter season will vary with prevailing conditions. One or two may suffice for northern Montana, while more frequent determinations may be required in the Pacific Northwest due to the warm Chinook winds.

The rainfall and runoff measuring stations are inspected, the clocks are wound, and the charts changed once a week during dry weather. The time indicated by the rain gage and water level recorder clocks is checked against a standard timepiece carried by the observer and recorded on the charts and in field books provided for this purpose. The necessary corrections are applied in compiling the data.

In addition to the weekly inspections, the stations are visited during and immediately after every rain. During these visits, the readings of the water level recorders are checked against the outside staff gages, and the readings of the recording rain gages are checked against the measured rainfall collected in the standard rain gages.

Permanent Characteristics of the Drainage Basins. The permanent characteristics of the drainage basins and the conditions existing at the time runoff occurs must be known, if the resulting data are to be useful in arriving at the laws governing runoff. This information is also required in order to apply the data to other locations within the runoff problem area represented by each of the drainage basins under investigation.

The permanent characteristics of small drainage basins affecting runoff include (1) length and degree of surface slope, (2) configuration of the surface, (3) drainage pattern and drainage density, (4) lengths, slopes, shape, and cross-sectional areas of watercourses, (5) improvements, such as terraces, structures, buildings, etc., (6) exposure or aspect of the various parts of the drainage basin, (7) depth, texture, and structure of the soil and subsoil, and (8) permanent vegetal cover, such as woodlots and grasslands.

To secure the information on the above characteristics detailed topographic maps on scales from 1 in = 100 ft to 1 in = 1000 ft are made, with contour intervals of 2 ft or larger, depending on the size and steepness of the areas. More detailed surveys are made of the temporary pond created by the measuring weirs during high flows in order that the discharge can be corrected for storage. The topographic maps of the temporary ponds are plotted on a scale of 1 in = 20 ft, with a contour interval of 0.5 ft. From such topographic maps, the information listed under (1) to (6) above is readily obtainable.

Detail soil surveys giving the characteristics and depth of the topsoil, subsoil, and the parent material are made. The information is plotted on the topographic map. Longitudinal and traverse sections of the drainage basins are prepared to show the variation in depth of soil over the various parts of the watershed. The permanent vegetal cover is accurately determined and plotted on the topographic map.

Conditions of the Drainage Basins. The variable conditions affecting runoff include (1) the moisture content or degree of saturation of the soil and subsoil, (2) the temperature of the soil, (3) the tillage of the soil, and (4) the type, density, and condition of crops or of grass and timber cover.

A careful record of rainfall and temperature conditions during periods preceding runoff will be kept on each of the projects. A set of maxima and minima thermometers and a hygrothermograph are included in the equipment for each project. Soil temperatures will be determined by means of thermocouples and soil thermographs. Soil moisture conditions will be determined by field examination and by means of simplified moisture determinations wherever possible. The condition of crops and other vegetal cover will be indicated on maps accompanying the record of every runoff period.

There has been considerable criticism of the common practice to withhold the publication of basic data until they are completely analyzed. It is true that some types of runoff data may be misleading if they are prematurely published without an adequate analysis. This is especially true in the case of data collected for the purpose of determining effects of various practices. The data to be collected from the runoff studies, however, do not fall in this category. The need for the information is so urgent that it is imperative to disseminate it as soon as it becomes available without waiting until final analyses are made.

The data must be compiled in such a manner as to include all the pertinent records so that the information can be utilized by engineers in the design of hydraulic structures and by students of runoff phenomena in subjecting them to such study and analysis as they may be capable of making. There are many eminent hydrologists outside of the government service who are as qualified to make full

use of such information, if not more so, than government employees. This is fully recognized by the Soil Conservation Service and by other government agencies, such as the Weather Bureau, the Geological Survey and others. The preliminary publication of the data collected on the erosion experiment stations (5, 6, 7, 8, 9) prove the earnest attempt to make available as much of the data as possible without delay.

A method of compilation is being developed which will enable the distribution of the collected information at the end of every season of precipitation with a minimum expenditure of time and money. This method involves the preparation of data sheets for individual runoff periods on each of the watersheds under investigation. Such sheets will contain a full description of the permanent characteristics of the drainage basin and of the conditions of the watershed at the time runoff occurs, the runoff hydrograph, the mass curve of current precipitation, and a record of antecedent conditions and precipitation, as well as a record of current and antecedent temperatures.

One must not conclude, however, that the work of the Service will be limited to the collection and compilation of the information. On the contrary, it is planned not only to analyze the information resulting from these studies, but to compile and analyze all existing rainfall records and other pertinent data in the various runoff problem areas in such a manner as to make possible the application of the resulting runoff data to the entire problem area. The application of the data will be extended to wider areas by means of records secured from artificial rainfall test plots on other areas to which the runoff data are to be applied.

The runoff studies are conducted by the Divisions of Operations and Research of the Soil Conservation Service.

The studies were planned and the technical phases of the work are directed by the Washington office of the Section of Watershed and Hydrologic Studies. The section of engineering of the Division of Operations was the prime mover in getting the work started and is constantly on guard to remove such administrative difficulties as arise from time to time. The regional engineers, the project managers, and the engineers assigned to these studies on the individual projects have generally shown great interest in this work.

Considerable progress was made within the last year, and it is expected that all the installations on the 21 projects will be completed before July 1, 1938. The location of the runoff studies and the number of drainage basins under investigation on each project as well as the locations of the experimental watersheds, are shown in Fig. 8.

The characteristics of the drainage basins and the status of construction on April 25, 1938, is shown in Table 1. It will be noted from this table that the installations have been completed and records are being obtained from 17 drainage basins on 5 demonstration projects. The work on practically all other projects is actively under way. Table 1 also gives the sizes of the areas, the slope, soils, vegetative cover, and the approximate discharge capacity of the weirs.

CONCLUSION

In conclusion, the author wishes to point out the great importance of these studies to engineers and students of runoff phenomena. They represent the first opportunity to secure a large amount of information which will be collected and made available in a standard manner. It is estimated that records of about 4,000 to 6,000 runoff-producing rains will be obtained each year from all of these studies. If the work is conducted as outlined for a number of years, it will result in an unequalled contribution to the science of hydrology and to the engineering and other professions, and will undoubtedly result in the saving of vast amounts of public and private funds.

It is gratifying to know of the great interest in these studies shown by many technicians and administrative officers of the Service and especially by practicing engineers and hydrologists outside of the Service. That the collected data are urgently needed and are extremely useful can be shown by an interesting incident. The author completed the installation of the recorders at the Edwardsville, Ill., project on March 12. Between March 15 and April 15 several significant rains occurred. The resulting records proved so important in connection with a large project now under consideration in the vicinity of St. Louis that the consulting engineer (an eminent hydrologist) sent members of his staff to Edwardsville to copy the records. This hydrologist recently told the author that the Edwardsville records will be of great value to engineers and public agencies engaged in the planning and construction of hydraulic structures and projects in the Middle West. The value of the records to the Soil Conservation Service is, of course, obvious.

REFERENCES

1 D. S. Myer. "Soil Conservation Districts," AGRICULTURAL ENGINEERING, March 1938.
2 T. A. Munson. "Formulas and Methods in General Use by Engineers to Determine Runoff from Watershed Areas," The Texas Engineer, April 1934.
3 C. S. Jarvis and others. "Floods in the United States," U. S. Geological Survey Water Supply Paper 771.
4 C. E. Ramser. "Runoff from Small Agricultural Areas," AGRICULTURAL ENGINEERING, vol. 34, no. 9, May 1927.
5 G. W. Musgrave and R. A. Norton. "Soil and Water Conservation Investigations," Soil Conservation Experiment Station, Clarinda, Iowa, progress report, 1931-35, Tech. Bul. No. 558, February 1937.
6 P. S. McGrew and G. M. Horner. "Soil and Water Conservation Investigations," progress report, 1931-35, Pacific Northwest Soil Conservation Experiment Station, Pullman, Wash., SCS-ESR-2, April 1937.
7 M. O. Hill, H. M. Elwell and J. W. Slosser. "Soil and Water Conservation Investigations," progress report, 1930-35, Red Plains Soil Conservation Experiment Station, Guthrie, Okla., SCS-ESR-3, July 1937.
8 O. E. Hays and V. J. Palmer. "Soil and Water Conservation Investigations," progress report, 1932-35, Upper Mississippi Valley Soil and Water Conservation Experiment Station, La Crosse, Wis., SCS-ESR-1, Sept. 1937
9 H. O. Hills, S. J. Mech and J. B. Pope. "Soil and Water Conservation Investigations," progress report, 1931-36, Arkansas-Louisiana-East Texas Lands Soil and Water Conservation Experiment Station, Tyler, Tex., SCS-ESR-4, January 1938.
10 F. T. Mavis and Edward Soucek. "A Summary of Hydrologic Data, Ralston Creek Watershed," 1924-1935, University of Iowa Studies in Engineering, Bul. 9, December 1936.
11 C. G. Bates and A. S. Henry. "Forest and Stream-Flow Experiment at Wagon Wheel Gap, Colorado," (final report), Monthly Weather Review Supplement 30, 1928.
12 A. W. Sampson and L. H. Weyl. "Range Preservation and Its Relation to Erosion Control on Western Grazing Lands," U.S.D.A. Bul. 675.
13 Metcalf and Eddy. "American Sewerage Practice," vol. 1, 2nd ed., 1928.
14 M. M. Bernard. Discussion of "Flood Flow Characteristics," by C. S. Jarvis. Trans. Amer. Soc. of Civ. Eng., vol. 89, 1926.
15 E. P. Arneson. "Rational Runoff Theory Applied to Design of Road Ditches and Channel Changes," The Texas Engineer, July 1932.
16 R. E. Horton. "Hydrologic Interrelations of Water and Soils," November 1936, Proc. Soil Science Soc. of America, vol. 1.
17 C. E. Ramser. "Brief Instructions on Methods of Gully Control," August 1933.
18 C. E. Ramser and D. B. Krimgold. "General Working Plan for the North Appalachian Experimental Watershed," November 1935.
19 C. E. Ramser. "Hydrologic Investigations on Selected Watersheds," Soil Conservation, February 1938.

What Agricultural Engineers Are Doing

FROM THE U. S. BUREAU OF AGRICULTURAL ENGINEERING

S. H. McCRORY, chief of the Bureau of Agricultural Engineering, sailed for Europe August 31 on SS President Harding. He plans to visit England and Ireland, France, Belgium, Holland, and possibly Germany and Italy. In Ireland and Belgium he plans to visit the retting plants in connection with studies the Bureau is undertaking in Oregon on the production of flax fiber. In England he will visit cotton spinning plants that are using American cotton, to observe condition of this cotton and particularly the amount of foreign matter in it as bales are opened. He will also study the latest equipment for hay drying in use there.

For some years specialists in England and Holland have been doing work on the stabilization of sandy foreshores by the use of vegetation. Mr. McCrory will observe this work in order to determine if similar methods can be used in connection with the design by this Bureau for the Biological Survey of a number of migratory waterfowl refuges along the sea coast.

In Italy Mr. McCrory will visit the Pontine Marshes. He plans to return to the United States about the end of October.

* * *

Leslie Bowen, assistant irrigation engineer, who for the past six years had been engaged in duty-of-water experiments at Scottsbluff, Nebr., died on August 26.

Mr. Bowen received the degree of B. Sc. from Utah Agricultural College in 1920, and his master's degree from the same institution in 1924. For five years he taught mathematics and during eight summer seasons he conducted hydrographic studies. In 1922 he was city engineer of Spanish Fork, Utah. In 1928 he was appointed hydrographer and instrument man with the Biological Survey, and in 1929 assistant irrigation engineer in the same Bureau. He was engaged on drainage investigations on Kootenai River, Idaho, in 1931-32 and in 1932 took up the work at Scottsbluff, Nebr.

Mr. Bowen was highly esteemed by his associates for his fine qualities and his achievements in research.

* * *

The first public demonstration of the "availabilimeter", designed by R. B. Allyn for determining the amount of moisture in soil available for plant use, was given August 26 at a field day held at Medford, Oregon, under the auspices of the Oregon Agricultural Experiment Station and the Fruit Growers' League. Field calibrations are being made on approximately 25 irrigation plots to verify previous laboratory calibrations made with this instrument. Moisture determinations made by the availabilimeter and duplicated by the oven method have shown remarkable agreement. It is expected that with corrections now in progress, deviation in results indicated by the two methods will be reduced to 2 per cent. By means of the availabilimeter, moisture samples at five locations at each of the three-foot levels, 15 samples in all for an entire plot, can be taken and the moisture determinations made, all within 30 min, whereas the oven method, with the necessary calculations for this number of samples, usually requires three days.

* * *

Contributions Invited

All public service agencies (federal and state) dealing with agricultural engineering research and extension, are invited to contribute information on new developments in the field for publication under the above heading. It is desired that this feature shall give, from month to month, a concise yet complete picture of what agricultural engineers in the various public institutions are doing to advance this branch of applied science.—EDITOR.

In the San Fernando Valley, California, there are about 12,000 acres of citrus crops. Approximately 70,000 acres have been planted to various crops, but much of this land has been subdivided for residential areas. About 25,000 acres of new land are available for cultivation. In connection with the survey of agricultural conditions, to be undertaken in this valley, conferences were held by Messrs. A. T. Mitchelson, Paul A. Ewing, Harry F. Blaney, Colin A. Taylor, and Dean W. Bloodgood, with officials of the Los Angeles Water Department and the Los Angeles County Farm Bureau, at which it was decided that Mr. Ewing, in cooperation with members of the staff of the University of California, would undertake the first part of the survey, a report on which would be completed within four months. Part II will consist of research studies on water utilization, in cooperation with the Bureau of Water Works and Supply of the City of Los Angeles, to which Messrs. Taylor and Bloodgood will be assigned. Both studies are to be coordinated under the general supervision of Mr. Blaney. The latter study is expected to extend over a period of at least five years.

* * *

In connection with the study of irrigation possibilities in South Dakota, Dean C. Muckel conferred with many county officials, farmers and others concerning prospects for irrigation projects. He also gave advice concerning location of wells, installation and testing of pumps, preparation of land for irrigation, etc. A number of wells are being drilled under the direction of the Works Progress Administration.

* * *

Under the Snow Survey and Irrigation Water Supply Forecasting project, J. C. Marr made a 3,000 mile trip covering snow courses in northern Nevada, southeastern Idaho, western Wyoming and western Montana. Three new snow courses were added to the present network. Tentative plans were made for cooperation with the state engineer of Montana and the Montana Agricultural Experiment Station. Mr. Marr found that the snow survey work of the Bureau in all of the regions visited is looked upon as work of great value and is being enthusiastically supported. A manual is being prepared for snow surveyors. L. T. Jessup made extensive trips in Washington, Idaho, and Montana, inspecting snow courses, consulting with supervisors and rangers, and surveying and relocating courses. R. A. Work made an extensive trip in Oregon for the purpose of making short-wave radio installations, locating and marking snow courses, and completing final arrangements for snow survey shelter cabins.

* * *

Colin A. Taylor reports that the machine designed by him for laying out broad, flat irrigation furrows has been fitted with folding wings so that 2, 3, or 4 furrows can be made as desired, since most orchards have some odd corners in which 4 furrows can not be made. With the folding wings, the machine is flexible enough to work under any practical orchard conditions. The machine was used on 20 acres at Glendora, Calif., on which weeds had been allowed to grow in the previous flat furrows until mature. The orchard was then disked lightly and the new furrows made so that they split the old ridges and covered the weeds in the bottom of the old furrows. This alternation of the position of ridges and furrows is of advantage in control of salts, as well as soil moisture. On the Rancho Sespe in Ventura County, California, 700 acres are now under broad-furrow irrigation, and great saving in labor cost has been effected thereby.

* * *

A new project on corn storage investigations financed by allotment from the Bankhead-Jones special research fund has been established with headquarters at Ames, Iowa. Dr. H. J. Barre is in charge of this project, his salary being paid jointly by the Iowa Experiment Station and the Bureau. The new investigations will deal primarily with the corn storage situation as it exists on farms. Surveys in cooperation with the respective state experiment stations and the state and county agricultural conservation committee are now being made in selected counties in Minnesota, Indiana, and Iowa. In addition to Dr. Barre, Messrs. David Atkins and Silas M. Henderson have been added to the staff. Mr. Atkins is a licensed grain inspector and will determine grade of corn samples taken from cribs surveyed. Mr. Henderson is a graduate of Simpson College and has had one year of agricultural engineering at Ames. This new field study of corn storage conditions is in addition to the experimental work begun last year at Ames and Urbana. Dr. Barre will work with Thayer Cleaver and W. R. Swanson, thus coordinating the work under the three projects.

* * *

A study of potato storage in the Red River Valley in cooperation with the North Dakota Agricultural Experiment Station is being undertaken. M. G. Cropsey will represent the Bureau in this work. A. D. Edgar visited a number of the houses in August with Mr. Cropsey, H. F. McColly and other representatives of the North Dakota Experiment Station, and is advising on the conduct of the investigation.

* * *

In a recent test at Arlington Farm, Va., of the continuous type portable wheat drier built by C. F. Kelly, wheat was dried at the rate of 85 bu per hour, the average moisture content being reduced from 14.35 to 12.4 per cent. While this is considered a good performance, modifications are being made to further increase the efficiency, if possible. *(Continued on page 452)*

* * *

NEWS

A.S.A.E. Sponsors School in Industry

INCREASED mutual understanding, respect, and cooperation between the farm equipment industry and the agricultural engineering departments of the colleges in the interest of better service to farmers was the prevailing spirit of a summer school in industry sponsored by the American Society of Agricultural Engineers, with the cooperation of five separate farm equipment manufacturers, and held September 12 to 16. It showed up early the first day, developed as the meeting progressed, was left with the company personnel visited, and carried home with the college men participating.

Sixty-seven faculty men and senior and junior agricultural engineering students were present from 23 colleges and universities, including Clemson Agricultural College, Mississippi State College, North Carolina State College, North Dakota Agricultural College, Oklahoma A. & M. College, Oregon State Agricultural College, Pennsylvania State College, South Dakota State College, Iowa State College, Kansas State College, Michigan State College, A. & M. College of Texas, Virginia Polytechnic Institute, Purdue University, Rutgers University, and the state universities of Georgia, Illinois, Louisiana, Minnesota, Missouri, Nebraska, Ohio, and Wisconsin.

Participating manufacturers, in the order visited, were Allis Chalmers Mfg. Co., Milwaukee, Wis.; J. I. Case Co., Racine, Wis.; International Harvester Co., Chicago, Ill.; Caterpillar Tractor Co., Peoria, Ill., and Deere and Co., Moline, Ill.

Prof. E. W. Lehmann, head of the department of agricultural engineering at the University of Illinois, was chairman of A.S.A.E. committee which brought the school to successful fruition after two years of study and investigation of possibilities. Early work on the proposition was advanced notably by the efforts of Prof. R. U. Blasingame, head of the agricultural engineering department at the Pennsylvania State College, originator of the plan. A member of A.S.A.E. connected with an industrial organization suggested a plan to the College Division at the annual meeting of the A.S.A.E. in 1936. Working together, the interested agricultural engineers in the colleges and the industry developed the program finally carried out.

The main purpose of the school, as stated in introductory remarks by Prof. Blasingame, was to give the college men an insight into the various departments of implement companies and an opportunity to form their own opinions as to the service rendered, and the manner in which it is performed, by the farm equipment industry for civilization in general and agriculture in particular.

It was mentioned in the course of the school that the whole purpose and justification for the farm equipment industry and for agricultural engineers in both public service and industrial employment, is to help farmers. As to methods, it was pointed out that by improved understanding and cooperation between the industry and the college agricultural engineers their service to farmers could be improved in several ways, such as (1) by the college men knowing how farm equipment manufacturers are organized and how they conduct their business, (2) by the students learning the training, personality, and performance requirements for employment and advancement as agricultural engineers in industry, (3) by the men in the industries getting better acquainted with the ideas, viewpoints, and personalities of the college men, (4) by helping teachers of power and machinery subjects to be better informed, and (5) by other incidental benefits of mutual acquaintance.

Emphasis was repeatedly placed on the fact that the object of the school was not to study particular machines or individual company developments, but rather to study methods typical of the industry, and the reasons behind those particular methods.

On successive days the programs featured design and development, manufacturing, merchandising, production methods and details, and materials, with some overlapping. Talks by company officials, college teachers, and students were interspersed with tours through laboratories and factories and with moving pictures. Activities started daily at 8:00 a. m., ran through the luncheon hour, and continued through the afternoon and evening dinner, with a minimum of short recesses. Traveling between cities was done at night.

Time was the only factor limiting the amount of information made available to the college men. Numerous and varied questions were asked frankly and as fully as possible. In spite of the strenuous program there was no "cutting classes" by the college men, and their sustained interest was matched by the time and attention given to the school by the presidents, vice-presidents, and other officials of the participating companies.

At the dinner marking the close of the school, Dr. J. B. Davidson discussed briefly the common field of service of agricultural engineers and the farm equipment industry. If we want to help agriculture, he indicated, we must ask ourselves, "What do we want for agriculture"? If we want a comfortable measure of well-being for people engaged in agriculture, with reasonable living conveniences and a good community life, he continued, we must consider how it can be accomplished. His view was that these advantages could only be realized on the family farm and by an exchange of services efficiently rendered by use of good equipment and engineering methods. He indicated as alternatives to this either small holdings and low production barely sufficient to maintain existence, or a serfdom with comfort and convenience for a few at the expense of practical slavery for the majority of farm workers.

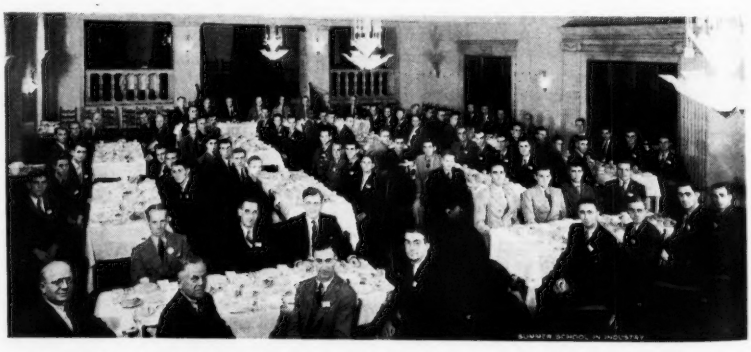
Apparent general feeling in regard to the success and value of the school was indicated by Cecil Robinson, who in speaking for the students present, said: "To get college credit for attending this school would seem like getting paid for eating ice cream."

Ag. Engineers to Take Part in Sugar Congress

THE Sixth Congress of the International Society of Sugar Cane Technologists meets in Louisiana from October 24 to November 5 as the guests of the State of Louisiana, the American Sugar Cane League, and the Louisiana State University. The first week will be spent in visiting some of the refineries, by-products plants, and a trip through the sugar cane belt. The second week will be spent on the campus of Louisiana State University with those in attendance divided up according to the various phases of sugar cane production and processing for the purpose of presenting and discussing papers pertaining to sugar production.

The agricultural-engineering phase of sugar production will include papers, discussions, exhibits, and field demonstrations. Such topics as drainage, deep seedbed preparation, rubber tires, harvesting, hauling, and windrowing will be featured on this program. Arrangements have been made for a large display of machines for use both in the United States and other countries. Some 200 foreign delegates are expected.

(News continued on page 452)



STUDENTS, TEACHERS, AND HOSTS OF THE SUMMER SCHOOL IN INDUSTRY SPONSORED BY THE A.S.A.E., AT ONE OF THE EVENING DINNER SESSIONS

HARVESTING A NEW CROP OF "CATERPILLAR" FACTS!

Here is a typical research project under way on the "Caterpillar" Proving Grounds.

Objective: To evaluate the influence of track grouser design on tractor performance.

Equipment: "Caterpillar" Diesel D4 Tractor, Drawbar Dynamometer and Loading Car. Ten types of grousers on the four surface conditions principally encountered by tractor users.

This project results in new facts about grouser function and design—and may provide the bases for improvements. Out of such studies, for example, "Caterpillar" has developed and pioneered all the principal types of grousers now employed on track-type tractors.

And these facts help bridge the gaps between manufacturer, salesman and user. The salesman, armed with the facts determined on this project, for example, can accurately recommend the grouser type that will most profitably meet his customers' conditions!

CATERPILLAR

REG. U. S. PAT. OFF.

TRACTOR CO. • PEORIA, ILLINOIS

DIESEL ENGINES TRACK-TYPE TRACTORS TERRACERS

A MILLION FARMERS

Minneapolis-Moline's new-day tractor heralds the approach of a new era in farming—combines unheard-of comfort . . . double utility . . . high compression economy.

As one of the sponsors of high compression, the Ethyl Gasoline Corporation is proud to join those who today acclaim Minneapolis-Moline's newest contribution to the welfare of the farmers of our country.

It is another of the many recent developments in tractor engineering and design which have been made possible by the adoption of powerful multi-cylindered, high compression tractor engines . . . engines built to take advantage of the excellent quality of the regular-grade gasoline now being sold by oil companies throughout the United States and Canada. Ethyl Gasoline Corporation, manufacturers of anti-knock fluids used by oil companies to improve gasolines.

THE MINNEAPOLIS TRIBUNE: SATURDAY SEPTEMBER 24, 1938

Tractor Brightens Farmer's Lot—Does Old Chores and Fancy New Tricks, Too

A big stride along the road to peak efficiency in farm operation was measured Friday, when the Minneapolis-Moline Power Implement Co. presented its new all-purpose tractor, a powerful but economical machine, streamlined in the 1939 mode, that can supply all the power—motive and stationary—needed on the average American farm.

This tractor can do all the work of the tractor of bygone days—and do it better—in powering farm implements, including plows, cultivators, binders, combines and every other kind of power-propelled machinery.

With a trailer, attached by a simple hitch, it can do more work and do it faster than a farm truck, and, with high clearance and high wheels cushioned by enormous rubber tires, can go places where no truck could travel. Deep sand, snow or mud, for example, would present no problem.

In the 30 seconds required for removing a detachable fender, the new M-M tractor can be converted into a stationary power plant, with a belt attached to a flywheel, driven by the crankshaft, furnishing energy to operate a grain separator, corn sheller, water pump or any other of the scores of machines on a farm.

For moving heavy loads about a farm or from farm to market, the tractor boasts a unique efficiency. It can pull as many trucks or wagons as can be hitched to it, and pull them fast.

Lastly, this all-purpose rig is

WILL BLESS THE DAY *this* TRACTOR WAS BORN

(September 23, 1938)

HERE ARE THE FEATURES THIS NEW TRACTOR OFFERS:

- Turret-top, all steel enclosed cab
- 4 plow power in the field
- 40 miles an hour on the highway
- Self starter
- Modern high compression engine
- Safety glass
- Ample power for heavy belt work
- Bendix brakes
- Head lights, utility spot light, tail light, stop light
- Imitation-leather covered automobile type seats
- Speedometer
- Radio, if desired—(you can hear it enjoyably in this quiet, insulated cab)
- Five speed synchro-mesh transmission
- Full variable speed governor
- Hot water heater for the cab
- Chassis engine and cab sealed against dust
- Greatly improved controls makes tractor handle easily
- Cigar lighter
- Windshield wipers
- Durable beauty finish
- 21-inch ground clearance
- Full vision—forward, back and sides

Washington News Letter

from AMERICAN ENGINEERING COUNCIL

A UNIVERSITY OF MANAGEMENT

SPONSORED by some twenty national technical, economic, statistical and business organizations, of which American Engineering Council was one, the Seventh International Management Congress brought together a remarkable group of leaders of industry and management, not only from the United States and Canada but from 20 additional nations. The paid registration was approximately 1,500.

In spite of the threat of world war which hung over the days immediately preceding the Congress, both special technical and general sessions were well attended, with participating audiences ranging from 100 to 500 individuals. In the technical sessions some 150 men contributed their experiences from countries abroad with a similar active participation from American conferees.

Management's responsibilities were clearly shown to have entered the professional field due to the advanced scientific methods of production. It was pointed out that to provide social security, there must be a reorientation of business to the great economic and social forces which now surround and control their own activities. That management must be conducted along the lines that would develop mutuality of interest of the executive and the workers, unifying the forces of government, business, labor, and agriculture towards one common goal. Sincere and honest work toward constructive industrial cooperation will in the end achieve that cooperation. This new concept of mutuality of interest must be foremost among the aims of enlightened industrial management.

Closely akin to the responsibilities emphasized in the management and industry relationship were those of management and labor, the problems of which must be settled outside of party politics. Emphasis was placed on the fact that the industrial owner must reduce his fixed charges so that idle workers will be given jobs, for otherwise a point will be reached where the rising tide of fixed charges on the government will become so great that they will not be able to collect taxes from the middle classes to pay those fixed governmental expenses. Labor, on the other hand, was induced to yield also and place their fundamental desires above those of party loyalty, so that they would not trade their vote for the power of their political labor boss, for the point was stressed that the political boss would turn a democracy into a class-conscious proletariat and a class-conscious plutocracy.

The technological progress within recent years had created new problems which management must face and solve wisely. While technological improvements may bring about temporary unemployment, management was instructed to so guide the change that it would be made in a manner which would afford generous protection to the workers affected by it, for efficiency should be tempered by humane consideration. Retraining workers, pensions, unemployment insurance, efficient employment agencies, and cooperation between other industries were offered as remedies. The predominate motive must be for the best ultimate services of the public rather than quick profits.

It was pointed out that technical progress has created opportunities for cultural development by affording the necessary time and facilities. That the ideal goal must be the reduction of Federal relief as rapidly as industry can take up the slack, leaving a minimum which will consist of those cases of unavoidable technological unemployment in the transition period between jobs.

Desirable social developments can only be realized through the action of two forces—the force of better technical developments, and the force of better management; the greatest management problem being that of determining the most advantageous balance between the two principles of decent group life and properly oriented operation. Management no longer represents a single interest but rather it functions on the basis of a trusteeship, endeavoring to maintain a proper balance of equity between the shareholder, the jobholder, the customer, and the public in general.

SECOND PUBLIC FORUM OF A.E.C. SCHEDULED FOR DETROIT NOVEMBER 11

The general subject of relation of research and of patents to the development of our American industrial system, with special reference to the engineers' relations to them, will form the broad subject of the second "Forum" of American Engineering Council, to be held in Detroit on Friday, November 11, at the Hotel Statler, with the Michigan Engineering Society as host to the American Engineering Council.

The program as planned, will open with a luncheon at which the first speaker will present what may be called the background of the question, devoting the afternoon to the specific contributions of research and its relation to industrial progress. The afternoon session will be devoted to the public consequences of the work of the scientist and the engineer and their interrelation will be developed in the discussion. The meeting will adjourn to an evening session, opening with a dinner at which the present patents system will be discussed with a special reference to its relation to the development of industry.

The proceedings of the two sessions will, it is hoped, constitute a contribution to this subject, which can be presented to the National Economic Committee of Congress as a factual contribution to its meetings during the early winter.

A special notice of this meeting with the time, place, names of speakers and other details will be issued early in October.

Authors

Deane G. Carter is author of a "Study of Rural Housing" published as Arkansas Agricultural Experiment Station Bulletin No. 364.

Marion Clark and *J. C. Wooley* are joint authors of Missouri Agricultural Experiment Station Bulletin 400 on "Terracing, an Important Step in Erosion Control."

ASAE Meetings Calendar

November 28-December 2—Fall meeting, technical divisions, The Stevens, Chicago, Illinois.

What Agricultural Engineers Are Doing

(Continued from page 447)

On September 7 Lewis A. Jones visited Vicksburg, Mississippi, to attend a conference with state authorities and Army engineers relative to the proposed survey of drainage conditions in the Yazoo Delta of Mississippi. The State Legislature of Mississippi recently appropriated $20,000 for such an investigation and the WPA has allocated $70,000 for the same purpose. The Mississippi State Planning Commission has requested the Bureau of Agricultural Engineering to supervise the work. J. T. Olsen, associate drainage engineer, has been assigned to have immediate charge of the work.

* * *

The Central District drainage camps during the month of August, 1938, completed 4,593,069 sq yd of clearing, 1,395,473 cu yd of excavation and embankment, 47,024 lin ft of tile reconditioning, and structural and other work, with the use of 97,104 enrollee man-days on the work; 21,092 enrollee man-days of the total number were used on structures and other miscellaneous work.

* * *

Early in September R. B. Gray visited the cotton production project at Auburn, Alabama, and conferred with R. M. Merrill and his associates concerning the work on tillage machinery. Plans were also discussed with E. D. Gordon relative to a trip to be made in October in Louisiana to study the needs of mechanization in sugar cane growing and to make a survey of what machinery development has already been attempted or is under way.

* * *

Mr. Gray also visited the T.V.A. projects and discussed with C. J. Hurd, acting chief of the Machinery Division, and others, the machinery development under way, contemplated and needed. Several interesting machinery developments were also viewed, including a hay drier using unheated air, a small thresher, a seeder for sowing small grass and fertilizer which sows the seed in a wide band and aids in preventing soil erosion.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the September issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Melvin E. Blessing, graduate assistant in agricultural engineering, Virginia Polytechnic Institute, Blacksburg, Va. (Mail) University Club.

E. A. Hodge, farm representative, rural electrification, Louisiana Power and Light Company, Hammond, La.

Wiley D. Poole, assistant agricultural engineer, Louisiana State Experiment Station, University, La.

TRANSFER OF GRADE

C. W. Chapman, assistant agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Americus, Ga. (Junior to Member)

Alvah E. Worth, assistant agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) 129 N. Broad St., Norwich, N. Y. (Assoc. Mem. to Member)

"Flash!

Here's another Goodyear sales help for tractor and implement dealers!"

ON September 26th, Goodyear launched its new radio program "Goodyear Farm Radio News."

This program follows—*and supplements*—the National Farm & Home Hour with *regional* broadcasts built to give farmers *local* news about crop reports, prices, shipping, weather forecasts and other vital information.

Prominent speakers and commentators are also presented—successful *local* farmers, businessmen dealing in farm products, farm group representatives, editors, and authorities *known in each region.*

Every weekday—from Monday through Friday—over 48 stations—from the Atlantic to the Rockies—and from Canada to Texas—these broadcasts bring *your customers* the information they want and need most, how to make more money, how to cut costs, how to grow better crops.

This program *can't help but make better customers for you!*

It's another step in Goodyear's far-sighted plan to build up its business *by helping you build up yours!*

TUNE IN!

Goodyear Farm Radio News

Every day—Monday through Friday
1:15 P.M. Eastern Standard Time
12:15 P.M. Central Standard Time
NBC Blue Network

GOODYEAR

TRACTOR TIRES AND OTHER PRODUCTS FOR THE FARM

Safety Precautions become more effective with ATLAS MANASITE BLASTING CAPS AND ELECTRIC BLASTING CAPS

How much safer?
In speaking of explosives, the factor of safety is always relative. But Atlas Manasite Detonators materially increase the margin of safety by lessening the chance of accident through inadvertent mishandling.

Why safer?
Atlas has developed an exclusive patented method of using hexanitromannite as an initiating compound. This has never been done before. This means a substantial reduction in sensitivity to impact and friction.

Are they full strength?
Yes. Greater safety has been attained without sacrificing detonating efficiency.

Special storage required?
No. They require only the usual methods of storage and application.

Have they been proved in operation?
Yes—in large numbers in all sorts of operations.

Do they cost more?
No!

Ask the Atlas Representative to tell you more about Atlas Manasite Detonators.

Another "ATLAS FIRST"

ATLAS POWDER COMPANY, WILMINGTON, DEL.

Cable Address—Atpowco

Everything for Blasting

OFFICES

Allentown, Pa.	Houghton, Mich.	Memphis, Tenn.	Pittsburg, Kansas	Seattle, Wash.
Boston, Mass.	Joplin, Mo.	New Orleans, La.	Pittsburgh, Pa.	Spokane, Wash.
Butte, Mont.	Kansas City, Mo.	New York, N. Y.	Portland, Oregon	St. Louis, Mo.
Chicago, Ill.	Knoxville, Tenn.	Philadelphia, Pa.	Salt Lake City, Utah	Tamaqua, Pa.
Denver, Colo.	Los Angeles, Calif.	Picher, Okla.	San Francisco, Calif.	Wilkes-Barre, Pa.

ATLAS EXPLOSIVES

CHEMICALS ATLAS EXPLOSIVES

Pack up your Troubles in *his* Old Kit Bag

U·S·S CARILLOY ALLOY STEELS
To strengthen vital parts such as springs, bearings, gears, etc. Special analyses for every purpose.

U·S·S STAINLESS STEELS
To permanently resist corrosion. To assure lasting beauty in hub caps, window frames, radiator grilles, and interior trim. To simplify cleaning and polishing—to add a selling advantage that will help dealers sell more cars.

U·S·S CONTROLLED STEELS
Carbon steels for forging, forming, heat treating and machining in which *all* quality *factors* are predetermined.

U·S·S HIGH TENSILE STEELS
To carry high unit stresses and to reduce weight to a minimum at low cost. (U·S·S COR-TEN has resistance to atmospheric corrosion 4 to 6 times that of plain steel).

U·S·S ABRASION-RESISTING STEEL
To reduce abrasive wear wherever earth, sand, gravel, waste, etc. flow over, through or against your equipment. Costs little more than plain carbon steel.

SPECIAL PURPOSE STEELS
USS
STEELS FOR EVERY PURPOSE

WHEN we say "Bring your steel problems to us"—it is not an empty phrase. It is a definite offer of assistance.

Today with more than 10,000 different alloys available to the steel user, steel making has become immeasurably more complicated. And so has steel buying.

To get the most value from your steel dollar you must match the steel you use to the special need for it. And that's quite a job. It presupposes a knowledge of the infinite variations in physical properties and chemical compositions of these special steels—of how differently they act in fabrication and perform in service—and most important of all, how they differ in ultimate cost.

That knowledge we are prepared to offer you.

Our corps of metallurgical contact men is trained to know all there is to know about custom-made steels. When one of them steps into your plant his first duty is to find out what you want the steel to do, both in your shop and in your product—then to select the exact grade of steel that will do the best job for you at lowest cost. His job is to analyze your steel requirements and to interpret them to our steel makers in such a way that you get not only the right steel but get it exactly right again and again. Let *him* pack your troubles in his old kit bag.

CARNEGIE-ILLINOIS STEEL CORPORATION

Pittsburgh — *Chicago*

Columbia Steel Company, San Francisco, *Pacific Coast Distributors*

United States Steel Products Company, New York, *Export Distributors*

UNITED STATES STEEL

Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, assistant chief,
Office of Experiment Stations, U. S. Department of Agriculture.

SELECTING YOUR GAS STOVE, *A. E. Baragar*. Nebraska Sta. Circ. 55 (1937), pp. 20, figs. 10. The technical information reported in Bulletin 86 has been utilized as the basis for answers to the most important and typical inquiries received by the author in the past 2 yr from prospective purchasers of gas stoves. The questions and answers are grouped under price, performance of cooking top, performance of oven and broiler, construction, significance of the American Gas Association approval seal, and appearance. As a further aid to purchasers, a rating chart is given covering the more important points to be considered. Photographs are also included of the different types of surface burners.

SOIL AND WATER CONSERVATION INVESTIGATIONS: PROGRESS REPORT, 1932-35, *O. E. Hays and V. J. Palmer*. U. S. Dept. Agr., Soil Conserv. Serv., 1937, SCS-ESR-1, pp. [83], pls. 8. This report is the first summarization of experimental data from the La Crosse (Wis.) soil erosion experiment station of the Soil Conservation Service. The report is preliminary and has been prepared as one of a series of progress reports to be made available to interested technical workers of the cooperating agencies for critical study and discussion. It is a joint contribution of the Soil Conservation Service and the University of Wisconsin.

Special attention has been devoted to the determination of the causes of accelerated erosion in the region and the most effective methods for its prevention. The soils on which the experiments were conducted were the Clinton and Dubuque silt loams, both being typical of the Upper Mississippi Valley. Both soils are low in organic matter and require the addition of lime at the rate of from 2½ to 3 tons per acre for growth of legumes.

A study of different types of vegetative covering was made. Five different cover conditions were represented in the control-plat experiment, namely, fallow, corn, grain, clover, and bluegrass. The experiment with fallow land showed a loss of 20 per cent of the rainfall as runoff which carried 152 tons of soil per acre. Corn annually lost 89 tons of soil per acre in runoff; grain 14 tons, or one-tenth as much as fallow; and the clover or bluegrass control plat lost less than 1 ton. Corn in rotation lost 54 tons of soil per acre in runoff, compared with 89 tons where successive corn crops were grown. Barley as a grain crop in rotation lost 21 tons per acre, compared with a loss of 14 tons from barley annually.

Because of the recency of installation and the uncontrolled factors that have appeared, some of the terrace data are not considered conclusive. A few storms caused most of the annual losses. The combination of factors most favorable to such losses were (1) the condition of the soil and type and state of vegetative cover, (2) the amount of rainfall, and (3) the intensity of the rainfall. On July 5, 1935, one rain caused 40 per cent of the loss for that year. The rain of August 5 and 6 of the same year was more intense but caused less damage because of the soil condition, fuller root system, and the influence of corn foliage in reducing the beating effect of the rain. Control measures, both vegetative and mechanical, must be capable of controlling the effects of any factor or combination of factors.

Level terraces are not suitable for Clinton soil. Graded terraces not exceeding 3 or 4 in fall per 100 ft are the most satisfactory. Observations indicated that on Clinton and similar soils, watersheds from 60 to 70 ft long on from 12 to 8 per cent slopes, respectively, are the maximum spacings that may be allowed.

Other studies of the effect of length and degree of slope, terrace construction, and the relation of farm operations to successful use of machinery and terrace maintenance are described.

The data upon which these studies are based, and to which references are made in the text, are contained in the tables and charts of the appendix.

A PRELIMINARY REPORT OF AN INFILTRATION STUDY OF SOME PIEDMONT AND COASTAL PLAIN SOILS, *G. R. Free and G. W. Musgrave*. U. S. Dept. Agr., Soil Conserv. Serv., 1937, SCS-TP-13, pp. [10], pls. 5. Studies conducted by the Soil Conservation Service on the infiltration rates of Ruston sandy loam, Greenville sandy clay loam, Susquehanna clay loam, and other typical Piedmont and Coastal Plain soils are reported in a preliminary way.

The Cecil sandy loam, sandy clay loam, and clay loam represent three different degrees of erosion found on the Watkinsville, Ga., site. While the Cecil sandy loam is undoubtedly eroded to some extent, it nevertheless has an A-horizon 11 in thick. The Cecil sandy clay loam with a 3-in depth of A-horizon represents an intermediate degree of erosion, while the Cecil clay loam has been subjected to severe erosion which has entirely removed the sandy surface cover. The total infiltration during the 3-hr period on those three soils was 1.65, 1.26, and 0.28 in, respectively. It is clear that the presence of the coarse material of the original A-horizon is in this instance associated with a high rate of penetration of water into the soil.

Total infiltration during the 3-hr period on the Davidson soil was 2.47, while on the Iredell it was only 0.04 in, an amount insignificant from the viewpoint of any practical effect upon erosion control practices. Clearly, control measures on the Iredell must be designed to care for greater quantities of water than those on the Davidson soil.

The Ruston sandy loam with 8 in of A-horizon, the Greenville sandy clay loam with 3 in of A-horizon, and the Susquehanna clay loam with 4 in of A-horizon gave infiltration which totaled 6.18, 0.60, and 0.29 in, respectively, for the 3-hr period.

Results also are reported of turbidity tests on Ruston and Davidson soils.

THE DEVELOPMENT OF A FLOTATION PROCESS FOR THE CLEANING OF CLOVER SEEDS, *F. C. Dyer and H. L. McClelland*. Sci. Agr., 18 (1937), No. 2, pp. 60-101, figs. 36. The results of studies conducted at the University of Toronto are reported, the purpose of which was to develop a flotation process for the cleaning of clover seed. The film flotation process seemed to be the most promising, and this method was developed finally into a commercial means of freeing clover seed from the seed of bladder campion, night-flowering catchfly, and white cockle. Subsequently dodder and other weed seeds were added to the list.

The experiments showed that there are differences, previously unknown, in the wettability of the coats of seeds. The difference, in some cases, is sufficient to allow a good separation using a water bath alone. It is possible to increase the wettability of some seeds more than of others by the use of the proper reagent, and to decrease the wettability of others. The difference in wettability may be increased to such an extent as to make separation, difficult by other means, comparatively easy by flotation methods. Successful separation has been made from clover of bladder campion, night-flowering catchfly, white cockle, and dodder, and the principle may be capable of extension to other weed seeds.

A SEED DROPPER FOR CEREAL NURSERY ROWS, *L. C. Burnett*. Jour. Amer. Soc. Agron., 29 (1937), No. 5, pp. 419, 420, fig. 1. In a contribution from the Iowa agricultural experiment station a seed dropper is described which has been adapted from the chain-drive model planter. The tool consists of a belt operating in the bottom of a trough with an adjustable gate that may be set for different row lengths.

EFFECT OF ETHYLENE AND CERTAIN METABOLIC GASES UPON RESPIRATION AND RIPENING OF PEARS BEFORE AND AFTER COLD STORAGE, *E. Hansen and H. Hartman*. Plant Physiol., 12 (1937), No. 2, pp. 441-454, figs. 5. Working with Bartlett, Beurre Bosc, Comice, and Anjou pears gathered at approximately 10-day intervals beginning a month or so prior to and extending beyond the usual harvest season, the Oregon Experiment Station found that the effects of ethylene are confined definitely to the period preceding the stage in the life of the fruit when the maximum level in respiration has been reached. Results with fruits treated after delayed periods of storage showed clearly that ethylene treatment is effective only during the period of ascending respiratory activity. No increase in respiration or ripening was obtained with ethylene in the case of pears which had been held in cold storage for some time. The emanations from ripe pears were found to increase the rate of respiration and ripening in freshly gathered Bartlett, Comice, and Anjou pears.

(Continued on page 458)

SKF BALL BEARINGS ON CYLINDERS INSURE

COMBINE PROFITS

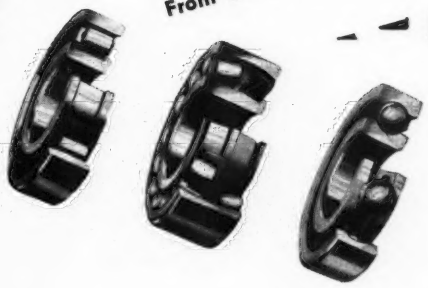
BUILT BY AVERY POWER MACH'Y CO. SKF-EQUIPPED

On the cylinder shaft, where close tolerances between cylinder and concave teeth must be maintained at a top speed of 1100 r.p.m., where dependability is essential and performance is the thing that counts . . . that's where SKF Ball Bearings serve this Model L 12-foot Combine.

SKF Bearings not only play an important role in assuring the prevention of grain loss on this machine. They also help to thresh 95% of the time with only two rows of concaves . . . to provide reserve capacity and low power consumption. Their rolling alignment, freedom from trouble and many other advantages give them a head start on rotating equipment of any kind. Next time you're in the market for agricultural machinery: Specify SKF Bearings, and buy the machine that's SKF-equipped.

SKF INDUSTRIES, INC.
Front St. & Erie Ave. Phila., Pa.

4173



SKF makes more types and sizes of ball and roller bearings than any other manufacturer in the world.

Agricultural Engineering Digest

(Continued from page 456)

BUILDING AND REMODELING DAIRY BARNS, *C. S. Rhode and W. A. Foster.* Illinois Sta. Circ. 478 (1937), pp. 27 + [1]. figs. 15. Practical technical information is given in the subject, together with working drawings and special features.

SURVEY OF SOIL CONSERVATION PRACTICES IN CENTRAL WEST TENNESSEE, *C. E. Allred, B. H. Luebke, and B. T. Lanham, Jr.* Tennessee Sta., Agr. Econ. and Rural Sociol. Dept. Monog. 59 (1937), pp. VII + 48, figs. 13. This report has been prepared by the Tennessee Experiment Station in cooperation with the Bureau of Agricultural Economics, the Agricultural Adjustment Administration, and the Soil Conservation Service of the U. S. Department of Agriculture. It reports a farm management survey of a total of 150 farms typical of central west Tennessee, the purpose being to show the prevailing type of soil conservation practices. Over 93 per cent of the farms surveyed in the area reported some kind of conservation practices.

RELATION OF SOIL CONSERVATION TO CONTROL OF FLOODS AND SILTING, *H. H. Bennett.* U. S. Dept. Agr., Soil Conserv. Serv., 1937, SCS-MP-17, pp. 7, pls. 4. This is a brief general statement on the subject presented at the National Rivers and Harbors Congress held in Washington, D. C., on April 26, 1937.

AGRICULTURAL ENGINEERING INVESTIGATIONS BY THE PENNSYLVANIA STATION. Pennsylvania Sta. Bul. 352 (1937), pp. 24-26. Progress results are briefly presented of investigations on efficiency of milk coolers, by J. E. Nicholas; use of tractors, by R. U. Blasingame and A. W. Clyde; artificial curing of alfalfa, by Clyde and S. I. Bechdel; harvesting potatoes and mechanics of tillage tools, both by Clyde; and precooling eggs on the farm, by Nicholas.

FEDERAL HIGHWAY PROGRAMS. U. S. Dept. Agr., Sec. Agr. Rpt., 1937, pp. 112-115. A brief statement is presented covering the progress of the work of the Bureau of Public Roads for the year 1937.

CONSERVING CORN BELT SOIL, *G. K. Rule.* U. S. Dept. Agr., Farmers' Bul. 1795 (1937), pp. [4] + 59, figs. 34. This publication treats in a general manner of erosion as a contributing cause to the decline of the natural productiveness of Corn Belt soils. Erosion practices now employed on the project areas of the Soil Conservation Service are discussed.

AGRICULTURAL ENGINEERING INVESTIGATIONS BY THE COLORADO STATION. Colorado Sta. Rpt. 1937, pp. 27, 38, 39. Progress results are briefly presented of investigations of sugar beet harvesting machinery, tests of an adjustable tube orifice meter, and the use of a single vortex-tube sand trap.

SOIL CONSERVATION DISTRICTS FOR EROSION CONTROL. U. S. Dept. Agr., Misc. Pub. 293 (1937), pp. 19, figs. 7. The purpose of this publication is to show how the Soil Conservation Service may cooperate with farmers through mechanism provided by state legislation covering soil conservation districts.

SOIL AND WATER CONSERVATION IN THE NORTHERN GREAT PLAINS. U. S. Dept. Agr., Soil Conserv. Serv., 1937, pp. 19, figs. 18. The purpose of this booklet is to analyze and explain the forces of erosion and to describe the conservation farming practices which the Soil Conservation Service is using in demonstration areas in the northern Great Plains region.

GUIDES TO TRAFFIC SAFETY. U. S. Dept. Agr., Bur. Pub. Roads, 1937., pp. III + 31. This report, prepared by the executive committee of the National Conference on State and Highway Safety, outlines methods suggested by experience for dealing with current pressing problems of street and highway safety.

DESIGN AND CONSTRUCTION OF THE DROP INLET SOIL-SAVING DAM, *C. L. Hamilton, et al.* U. S. Dept. Agr., Soil Conserv. Serv., 1937, SCS-EP-14, pp. [6] + 32 + [27], figs. 26. This is a joint contribution of the Soil Conservation Service and the University of Wisconsin. It deals with the drop inlet soil-saving dam and reports this work in technical detail.

AGRICULTURAL ENGINEERING. U. S. Dept. Agr., Sec. Agr. Rpt., 1937, pp. 99-102. A brief description is given of the work of the Bureau of Agricultural Engineering and its progress during the year 1937.

SOIL EROSION PREVENTION BY THE PUERTO RICO STATION. Puerto Rico Sta. Rpt. 1936, pp. 2, 17-23, figs. 3. Progress results of this work are presented. It has involved both the mechanical and the agronomic approach.

ANCHORING FARMLANDS IN THE OHIO VALLEY REGION, *J. S. Cutler.* U. S. Dept. Agr., Soil Conserv. Serv., 1937, pp. 18 + [2], figs. 19. This is a brief general statement of methods suggested by the Soil Conservation Service for the control of soil erosion in the Ohio Valley region.

THE TILE DRAINAGE EXPERIMENT. Indiana Sta., Jennings Co. Expt. Field Rpt. 1921-36, pp. 6, 7. Comparisons of different distances and depths are tabulated.

AGRICULTURAL ENGINEERING INVESTIGATIONS BY THE OREGON STATION. Oregon Sta. Bul. 350 (1937), pp. 36-38, figs. 2. The progress results are briefly reported of investigations on drying shelled corn by forced draft with heated air; electric hotbeds; artificial drying of hops; high-pressure pea sprayer; walnut, filbert, and prune drying; electrical soil sterilization; egg-room humidifier; and electric brooding.

NURSERY ROOT PRUNER FOR USE IN LIGHT SOILS, *W. F. McCulloch.* Michigan Sta. Quart. Bul., 20 (1937), No. 2, pp. 92, 93, fig. 1. This equipment as developed by the station is briefly described and illustrated.

1936 TRACTOR COSTS IN MICHIGAN, *H. B. Taylor.* Michigan Sta. Quart. Bul., 20 (1937), No. 2, pp. 76-79. Data are reported on yearly and hourly costs and on relation of hours of use to tractor costs and to farm operating efficiency.

REPORT OF THE CHIEF OF THE SOIL CONSERVATION SERVICE, 1937, *H. H. Bennett.* U. S. Dept. Agr., Soil Conserv. Serv. Rpt., 1937, pp. 51. This report deals with the operations and research activities of the Soil Conservation Service.

It is pointed out that in 18 states legislative action authorizing the formation of soil conservation districts opened for the first time an avenue through which individual and governmental initiative can be exerted in extending soil conservation practices to agricultural land.

The statement on research indicated that 13 soil erosion experiment stations were in operation during the year and 6 additional stations were being developed.

Progress results are reported on studies of watersheds, geography and climate, sedimentation, hill culture, and the economics of soil conservation.

WILDLIFE CONSERVATION THROUGH EROSION CONTROL IN THE PIEDMONT, *R. O. Stevens.* U. S. Dept. Agr., Farmers' Bul. 1788, pp. II + 26, figs. 20. This shows in a practical manner how gullies, terrace outlets, waterways, eroding field borders, pastures, and woodlands in the Piedmont region may be protected against erosion through the use of vegetation that will also provide food and cover for wildlife.

REPORT OF THE CHIEF OF THE BUREAU OF AGRICULTURAL ENGINEERING, 1937, *S. H. McCrory.* U. S. Dept. Agr., Bur. Agr. Engin. Rpt., 1937, pp. 24. This report presents progress results of investigations conducted in the subjects of farm structures, land drainage, irrigation, mechanical equipment, farm operating efficiency and cotton ginning. Outstanding progress is reported in the development of supplemental irrigation practices, forecasting irrigation water supplies, water spreading, mechanical placement of fertilizer, preparation of land for cotton, sugar beet harvesting, vapor spraying, and potato storage.

AGRICULTURAL ENGINEERING INVESTIGATIONS BY THE ALABAMA STATION, *R. E. Yoder, M. L. Nichols, F. A. Kummer, A. Carnes, and E. G. Diseker.* Alabama Sta. Rpt. 1934-35, pp. 9-12. The progress results are briefly reported of investigations on a method for making aggregate analysis of soils, the physical nature of erosion losses from Cecil clay, adhesion between soil and metal surfaces, development of mathematically perfect plow surfaces for experimental work, soil crust formation and its relation to cotton stands, and the effect of various crops on soil erosion control.

FEED GRINDING, MIXING, AND ELEVATING, *H. N. Colby.* Washington Sta. Pop. Bul. 151 (1937), pp. 28, figs. 18. This report has been prepared in cooperation with the Washington Committee on the Relation of Electricity to Agriculture. It gives practical information on the mixing, grinding, and elevating of feeds, using electricity as the source of power. *(Continued on page 460)*

TIMKEN Renewable Pumping Units

REDUCE SERVICING DELAYS TO THE VANISHING POINT

All pre-conceived ideas of fuel injection equipment operation and maintenance had to be revised when the modern developments now embodied in TIMKEN Fuel Injection Equipment were introduced—for these developments are designed to overcome many difficulties experienced in the field.

Five major factors govern the efficiency, dependability and life of fuel injection equipment. They are (1) manufacture; (2) material; (3) care; (4) protection; (5) fuel oil. Let's see how TIMKEN Fuel Injection Equipment measures up to them.

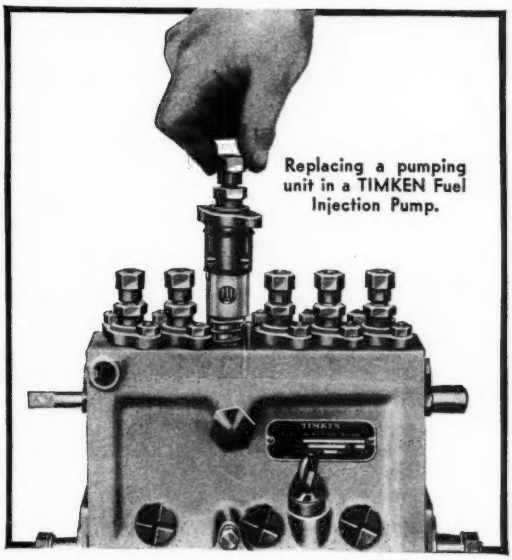
(1) The Timken Roller Bearing Company has a world-wide reputation for precision manufacturing. No organization in this country or abroad is better fitted to assure the extreme accuracy essential in fuel injection equipment.

(2) TIMKEN Electric Furnace Steel especially developed for the purpose, assures the tremendous strength and wear resistance the vital parts of fuel injection equipment must have.

(3) The Timken Fuel Injection Equipment Instruction Book has taken the mystery out of fuel injection. It enables any truck driver or garage mechanic to thoroughly understand the construction and operation of TIMKEN Fuel Injection Equipment and to service it in the field when necessary.

(4) Thorough protection against the external entrance of dust and dirt into the mechanism of the TIMKEN Fuel Injection Pump is provided by the dirt-proof housing.

(5) Fuel oil containing acid, dirt, or both is very injurious to fuel injection pumps and nozzles. This is a condition the fuel injection equipment manufacturer cannot control. In TIMKEN Fuel Injection Equipment, however, we have provided the means to repair such damage promptly and economically through easily renewable pumping units, nozzles and other vital parts. This can be done by any engine operator. No expert assistance is required, neither is it necessary to incur the delay and expense of shipping the equipment back to the factory for repairs.



Replacing a pumping unit in a TIMKEN Fuel Injection Pump.

It will pay you to consider all of these points carefully when buying new fuel oil burning engines of any type.

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

TIMKEN

FUEL INJECTION EQUIPMENT

Agricultural Engineering Digest

(Continued from page 458)

MAJOR TEXAS FLOODS OF 1936, *T. Dalrymple et al.* U. S. Geol. Survey, Water-Supply Paper 816 (1937), pp. V + 146, pls. 12, figs. 33. This report, prepared in cooperation with the Federal Emergency Administration of Public Works, deals primarily with June, July, and September storms and the resultant floods of 1936 and includes a brief summary of available information about previous floods.

SPREADING WATER FOR STORAGE UNDERGROUND, *A. T. Mitchelson and D. C. Muckel.* U. S. Dept. Agr., Tech. Bul. 578 (1937), pp. 80, pls. 22, figs. 38. This bulletin presents a large amount of information obtained from various experimental studies on the spreading of water for storage underground.

The conclusion is drawn that spreading water for underground storage is no longer an experimental undertaking and presents great possibilities. Apparently it can be practiced with more or less success in any region where pumping from wells is the principal means of furnishing water supply. In many cases it has been found more economical than surface storage, because the works necessary for storage are not as extensive or costly, and there is no evaporation loss.

It has been found that, other factors being equal, the highest percolation rates are returned on land with the native vegetation and soil covering least disturbed. It appears that the consumptive use by vegetation is negligible in comparison with its beneficial effect on the percolation rate.

Although temperature has some effect on the rate of percolation, the change in temperature of the water during the spreading season is usually so small that its effect is overshadowed by other more important factors, and furthermore, it is an uncontrollable factor in the spreading of flood waters.

The ground water has no marked effect on the percolation rate until it comes in actual contact with the saturated soil extending a few inches below the ground surface. When this contact is made a very sharp decrease in the rate of percolation takes place. Maximum percolation rates are obtained during the period the groundwater level drops after it has made contact with the ground surface. The reason for the maximum rates at this time is not definitely known, but is probably due, in part, to the partial vacuum formed by the falling water table. The ground surface is sealed by the spreading water which is then drawn underground as the vacuum is created. The effect of the dropping water table on the percolation occurs only during the first few feet of drop.

Percolation rates in basins or ponds, with the vegetation removed, decrease with the continued application of water. This decrease is due to re-sorting of the soil particles and puddling of the soil surface.

Higher rates of percolation in basins may be maintained by frequent harrowing or raking of the ground surface. Water containing silt should not be spread in still pools, such as basins or ponds. In the ditch system of spreading, carrying velocities should be maintained so as to insure the carriage of suspended matter throughout the length of the ditches. Because of the high cost of sinking shafts or pits, their use is not economical if surface spreading can be employed. On streams subject to large floods, adequate works should be provided to completely control the amount of water diverted at all times. Reception ditches are recommended at the lower boundaries of spreading areas in order to return excess water back to the stream of origin and provide protection to lower lands.

LABOR, POWER, AND MACHINERY IN CORN PRODUCTION, *C. K. Shedd, E. V. Collins, and J. B. Davidson.* Iowa Sta. Bul. 365 (1937), pp. 187-222, figs. 20. This bulletin reports the results of investigations conducted by the station in cooperation with the U. S. D. A. Bureau of Agricultural Engineering.

It has been found in general that commercial corn production cannot be carried on satisfactorily by hand methods but can be done only with machinery. It appears that the operating costs in corn production depend greatly upon the efficiency of labor, power, and machinery management.

It was found that raking and burning cornstalks before plowing in preparing a seedbed for corn required 0.47 man-hour of labor and 0.38 tractor-hour of power per acre and appeared to be largely a waste of labor and power. Cutting stalks with a stalk cutter before plowing required 0.23 hr per acre for man and tractor, with no apparent benefit. Disking before plowing took 0.25 hr per acre for man and tractor, and seemed to be of doubtful value. With a plow that was designed and adjusted to cover trash, previous work on cornstalks was eliminated.

For the primary operation in preparing a seedbed for corn, the substitution of cheaper operations instead of plowing gave unsatisfactory results. Under favorable conditions, no measurable difference was found in the value of work done by the ordinary moldboard plow and the pulverator plow (one having rotating blades to pulverize the furrow slice as it is turned). Under very wet or very dry conditions the pulverator had some advantage.

For secondary operations in seedbed preparation, comparison of disk harrow and duckfoot field cultivators showed no difference in weed control or yield of corn.

The lever type of spike-tooth harrow was found preferable, under most conditions, to other machines tried for light operations in seedbed preparation. Drill planting was a faster operation than check planting. Weed growth was somewhat more effectively controlled in check-planted corn. Under ordinary soil conditions at planting time surface planting was preferable to the use of disk furrow openers. In a comparison of 42x42-in, 30x30-in, and 21x21-in check planting, it was found mechanically feasible to plant and cultivate in the narrow spacings, but the cost was a little higher than with standard spacing. Narrow spacing and single-plant hills produced a material increase in yield over that obtained by the usual method of check planting under favorable growing conditions in 1935. There was little if any increase under adverse conditions in 1934 and 1936. For early cultivation of surface-planted corn, a cultivator equipped with a pair of rotary hoe wheels near the row and six sweeps between rows gave the best results. Work done by spike-tooth harrow, weeder, and rotary hoe was not entirely satisfactory under some conditions. For cultivation of weedy corn the best results were obtained with a cultivator equipped with two pairs of disk hillers and one pair of sweeps per row. In the 3 yr, 1934-36, surface-planted corn yielded higher than listed corn. There was little difference in yield between listed and basin-listed corn. In basin-listed corn, seed drilled in a continuous row, without any synchronization with location of dams, did as well as any other placement of seed.

Harvesting a 70-bu yield of corn required 9 man-hours of labor per acre when done by machine. Timeliness tests of corn picker-huskers showed that the best period for machine harvesting began as soon as the corn was dry enough to crib and in 2 out of 3 yr ended the second week in November. Records of performance tests of corn picker-huskers are shown in detail. The amount of corn left in the field by these machines is probably the greatest obstacle to their universal use. With a high yield, twice as much labor was involved in hauling and cribbing the corn as in picking with a two-row machine; therefore, the equipment for hauling and cribbing should receive careful attention. Under some conditions corn may be harvested economically by a machine and one-man crew.

IMPROVEMENT HANDBOOK. U. S. Dept. Agr., Forest Serv., 1937, pp. XX + 446, figs. 126. The purpose of this handbook is to make available the methods and standards recognized as good practice in building structural improvements on the national forests. It contains chapters on preliminary planning for building developments; construction schedule and work plan; excavation; footings and foundations; piling and pile driving; wood preservation; protection against wood-destroying organisms; selection and use of wood products; millwork; light building construction; heavy timber construction; scaffolds and towers; log construction; concrete construction; building materials—selection and use; masonry and brick construction; steel erection; rigging; roofing materials; laths, plaster, and stucco; heating; electric service; plumbing; hardware; and painting and finishing work.

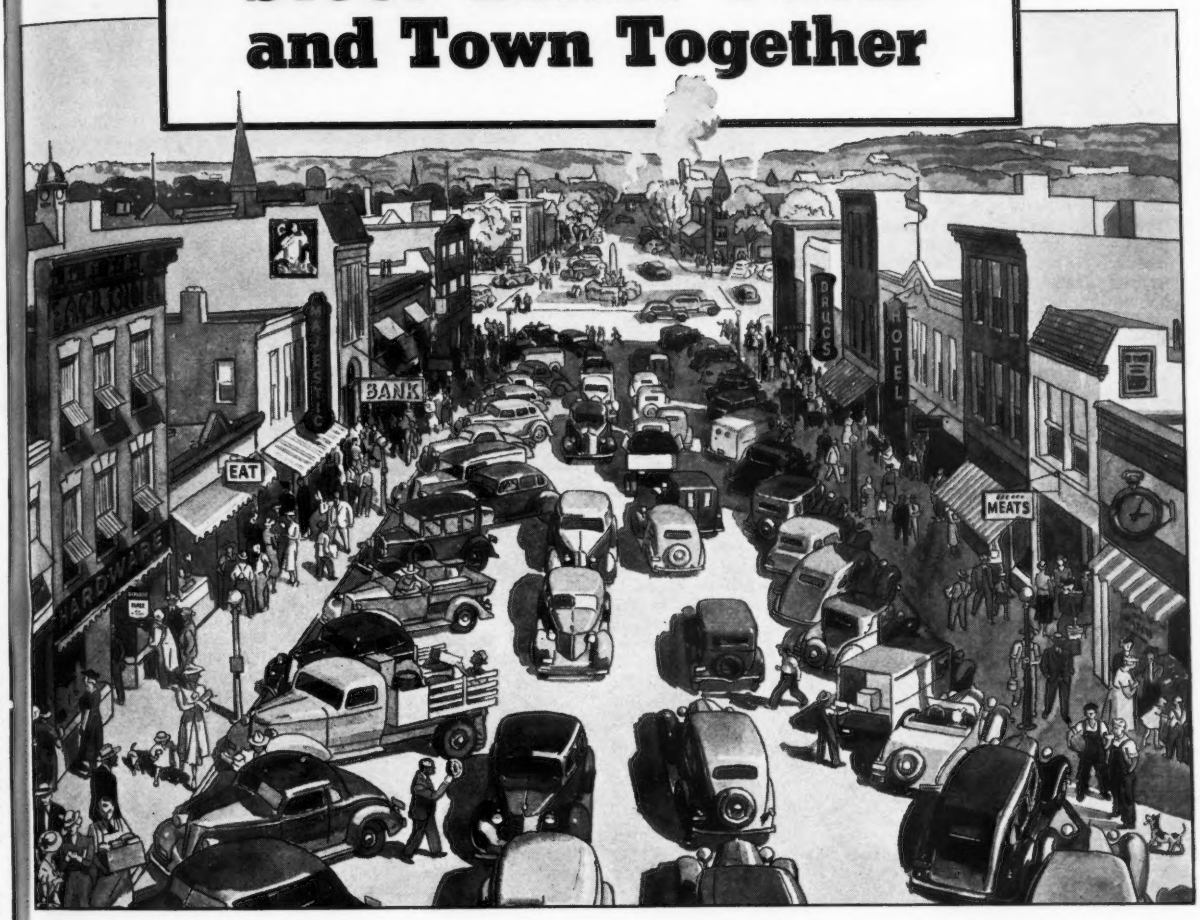
SEAL COATS FOR BITUMINOUS SURFACES, *A. R. Legault.* Colorado Sta. Bul. 440 (1937), pp. 22, figs. 9. The results of service tests of seal coats are reported, these being mainly with commercial materials. The findings are largely relative to the service character of the materials.

IMPLEMENTS AND METHODS OF TILLAGE TO CONTROL SOIL BLOWING ON THE NORTHERN GREAT PLAINS, *J. S. Cole and G. W. Morgan.* U. S. Dept. Agr., Farmers' Bul. 1797 (1938), pp. II + 21, figs. 12. Practical information is given on the subject.

ELECTRICAL MOISTURE METERS FOR WOOD, *M. E. Dunlap.* U. S. Dept. Agr., Forest Serv., Forest Prod. Lab., 1937, pp. [1] + 4. Instruments now available for the measurement of moisture in wood by rapid electrical methods are briefly described.

EFFECTS OF FEEDS AND SAW SPEEDS ON COTTON TURN-OUT AND QUALITY, *C. A. Bennett and F. L. Gerdes.* U. S. Dept. Agr. Leaflet 151 (1937), pp. 4, fig. 1. Practical information on the subject is given, based on tests at the U. S. Cotton Ginning Laboratories, Stoneville, Miss. *(Continued on page 462)*

Steel Binds Farm and Town Together



Republic Works Today on Agricultural Problems of Tomorrow

REPUBLIC sees a tremendous opportunity to serve the farmers of America by producing better products of steel—products that cut farm costs, lighten farm labor—and save the farmer's time.

Republic's fine line of farm fence, barbed wire, steel posts, and galvanized roofing, is already well known to thousands of farmers.

But Republic is looking ahead—and is preparing now, through science and research, to meet tomorrow's farm requirements.

Millions of dollars have been invested in modern plants producing alloys and special steels for scores of articles used on the farm.

Republic metallurgists and engineers, in finely equipped laboratories, are constantly testing, checking, and developing other new steels. And they are working closely with engineers of many other industries that serve the farm.

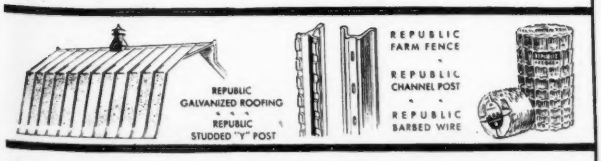
An Agricultural Extension Bureau has been set up to keep Republic in intimate touch with the farmer and his problems.

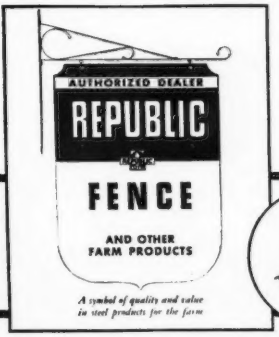
A research Fellowship has been established at one of the nation's leading agricultural colleges to help us give a broader and a better service. A sound motion picture, "Steel, Servant of the Soil", has been produced—and a comprehensive "Fence Handbook" by Professor Henry Giese of the Agricultural Department of Iowa State College is available to all who are interested.

Republic is building for the future—and has entered the agricultural field in a constructive, helpful way. Thousands of well rated, well-thought-of local dealers who personally know farmers and farm markets now represent Republic in the better agricultural trading centers of America. These men are binding farm and town more closely together with ties of steel.

Republic Steel Corporation
(WIRE DIVISION)
7250 South Chicago Ave. Chicago, Illinois
(General Offices: Cleveland, Ohio)
Farm Products Plants at: GADSDEN, ALABAMA, and CHICAGO

GULFSTEEL — REPUBLIC — REG. U.S. PAT. OFF. STEEL





How well do you know your local dealer?

Your Republic dealer is interested in you. You should be interested in him—for each of you helps the other. Plan to get better acquainted.

Agricultural Engineering Digest

(Continued from page 460)

AGRICULTURAL ENGINEERING INVESTIGATIONS BY THE ALABAMA STATION, *F. A. Kummer and D. F. King.* Alabama Sta. Rpt. 1936, pp. 9, 10, 15. Progress results are briefly reported of investigations on the relationship of the dynamic properties of soil to the elements of tillage implement design and sack-cement poultry house construction.

LAG-SCREW JOINTS: THEIR BEHAVIOR AND DESIGN, *J. A. Newlin* and *J. M. Gahagan.* U. S. Dept. Agr., Tech. Bul. 597 (1938), pp. 27, figs. 16. The purpose of this bulletin is to present the results of numerous lag-screw tests recently made at the Forest Products Laboratory in cooperation with the University of Wisconsin. These studies form a part of a more general investigation of wood joints and fastenings. The tests cover two main aspects of lag screw use and action, namely, resistance to direct withdrawal and resistance to lateral displacement. The lag screws used in the tests were of the machine-threaded type with a root diameter of thread approximately three-fourths that of the shank or unthreaded portion. They differed widely in quality of metal and in over-all length, and also in the relative length of shank and threaded portion, particularly among the various sizes. Seasoned material of both coniferous and hardwood species were used in the study.

It was found that in assembling wooden members with lag screws it is essential to use prebored holes except for the smaller screws in the softer species, and even there it is considered good practice. The lead hole for the entire shank should be of the same diameter as the shank. The recommended diameter of lead hole for the threaded portion in northern white pine is from 40 to 70 per cent of the shank diameter of the screw, in Douglas fir and southern yellow pine from 60 to 75 per cent, and in white oak from 65 to 85 per cent of the shank diameter. The larger figure in each range applies to screws of the greater diameters. Soap or other lubricant should be used on the screws, particularly with the denser species, to facilitate driving and prevent damage to the screw. Lead holes slightly larger than those recommended for maximum efficiency should be used with lag screws of excessive length.

The resistance to direct withdrawal of lag screws varies about as the 3/4 power of the shank diameter of the screws, about as the 3/2 power of the specific gravity of the wood into which they are driven, and directly as the depth of contact of the threaded portion. A depth greater than 7 times the shank diameter of the screw in the denser species and from 10 to 12 times in the softer species would develop a resistance approximately as great as the ultimate tensile strength of the screw.

The resistance to withdrawal of a lag screw from an end-grain surface is about three-fourths as great as from a side-grain surface of the same piece.

The resistance to lateral displacement of a lag screw bearing parallel to the grain of the wood varies about as the square root of the crushing strength of the wood along the grain and as the 3/4 power of its specific gravity. It also varies as the square of the shank diameter of the lag screw and about as the square root of the yield-point stress of the metal.

A cleat-thickness ratio below about 3.5 to 1 gives more or less erratic proportional limit loads. For ratios from 3.5 to 1 up to about 7 to 1 there is a considerable increase in proportional limit loads, but beyond this ratio the rate of increase in strength drops very rapidly.

In arriving at some of the more general deductions given here, full advantage was taken of information obtained from a very comprehensive series of tests of bolted joints in which the action for the greater ratios of length of bolt in main timber to diameter is very similar to that of lag screws.

ELECTRIC PIG BROODERS, *J. R. Tavernetti and E. H. Hughes.* California Sta. Bul. 618 (1937), pp. 8, figs. 2. This bulletin reports investigations conducted in cooperation with the California Committee on the Relation of Electricity to Agriculture. These included a series of trials to determine the practicability of electric pig brooders made during the spring farrowing seasons of 1935-37.

Electric pig brooders were successful in reducing the loss of pigs during the first 10 days after birth. In three years' trials the loss was reduced about 50 per cent. Practically no difference in results was obtained with the two types of brooders used, namely, underheat and radiant. The radiant brooder had certain advantages in cost and operation over the underheat. The initial and operating costs of the brooders was low enough to make their use economically feasible.

THE CONSERVATION OF MONTANA'S IRRIGATED LANDS, *P. L. Slagsvold and H. H. Lord.* Montana Sta. Bul. 350 (1937), pp. 32, figs. 8. The results of investigations are reported which were conducted in cooperation with the U. S. D. A. Bureau of Agricultural Economics and Agricultural Adjustment Administration.

The purposes of the study were (1) to determine the extent and nature of soil depletion on irrigated land in Montana and (2) to determine from a study of farm organization and soil management practices the adjustments which might be helpful in conserving the soil.

It was found that (1) erosion from poor use of irrigation water, (2) leaching and seepage, (3) failure to maintain a balance between soil depleting and leguminous soil conserving crops, (4) a deficiency in livestock numbers, (5) failure to use commercial fertilizer where needed, and (6) the encroachment of weeds upon farm land are active soil and fertility depleting factors on some farms in all of the irrigated areas studied. However, there is a notable difference in the frequency and severity of these factors in the different areas, growing primarily out of differences in the general type of farming and in farm practices.

Dairying, together with a large proportion of soil conserving crops in the Bitterroot Valley, and beet production, together with dairying and livestock fattening in the Yellowstone area, are farm organization characteristics which are maintaining and in some cases increasing yields on the better managed farms. On the other hand, a high proportion of cash grain which is not balanced by leguminous soil conserving crops, livestock, or commercial fertilizer is a factor contributing to soil depletion and low yields in the Sun River area.

Poorly constructed irrigation ditches and irrigation of unprotected sloping lands are resulting in an increasing erosion problem in some of the irrigated areas studied. Soil depletion from this cause could in many cases be reduced by running the ditches on a more gradual grade and by the protection of the more sloping farm land with grass and hay crops. Better use of irrigation water and avoidance of its waste would reduce soil depletion by leaching and would aid in reducing the seepage of lower lands.

Experimental evidence indicates that a fifty-fifty division between soil depleting and soil conserving crops, plus a livestock enterprise to provide a market for hay and pasture, and the conserving and skillful use of barnyard manure, is the general type of farm organization which seems adapted to the maintenance of an agronomic balance on the irrigated farms in the areas studied. The practice of plowing up the leguminous crops at regular periods might also be followed, especially where crop yields are not maintained through manuring.

Weed control is a serious problem in most irrigated areas and frequently requires community action for most effective handling.

SOIL EROSION IN OHIO, *G. W. Conrey, J. S. Cutler, and A. H. Paschall.* Ohio Sta. Bul. 589 (1937), pp. 32, figs. 10, map 1. This bulletin is designed to present the extent of the erosion problem in Ohio and to point out, in a general way, the relationship of erosion to land use. A generalized erosion map of the State made in connection with a national reconnaissance erosion survey of the United States is included. The map was compiled under the direction of the U. S. D. A. Soil Conservation Service, with the cooperation of the Bureau of Chemistry and Soils and the station.

As a result of studies made in Soil Conservation Service project areas and Civilian Conservation Corps camp areas, as well as cooperative studies made by the station and the U. S. D. A. Bureau of Agricultural Economics and Soil Conservation Service, it has been established that all sloping lands in Ohio fall into four main classes where land use is concerned. These are: (1) Those lands which may be cultivated under normal tillage conditions with minimum soil loss by erosion, (2) those lands which may be cultivated if special soil conserving measures are used, (3) those lands which should be kept permanently in grass or grass-legume cover in order to prevent erosion, and (4) those lands so steep that they should be kept under permanent shrub or tree cover if erosion is to be controlled. The slope percentages to be included in these various land-use classes vary with the soil areas.

ENGINEERING STUDIES BY THE WISCONSIN STATION. Wisconsin Sta. Bul. 439 (1937), pp. 40-48, figs. 2. Results are noted of studies by M. J. La Rock and E. C. Meyer on means to get better heated farmhouses; by F. W. Duffee and H. D. Bruhn to develop a small rotary sprinkler irrigation system; by Duffee, Bruhn, L. F. Graber, G. Bohstedt, B. H. Roche, and E. B. Hart on the effect of chopping hay on storage requirements; the design of hay storage structures; by Duffee and Bruhn on the increased safety of electric fence; and by Duffee on the use of dual rubber tires on tractors.

(Continued on page 464)

Safeguard

YOUR FARM MACHINES WITH THESE FAMOUS PRECISION INSTRUMENTS

STEWART WARNER ELECTRIC FUEL PUMP

Here's new and permanent freedom from fuel pump troubles for gasoline, Diesel, and fuel oil powered engines. This new Stewart-Warner Electric Fuel Pump eliminates vapor-lock, freezing, dirt and water contamination, or failure through structural breakdown.

New type electric unit provides diaphragm pump action without rotary motion! Highly efficient, this pump delivers required volume of fuel on a power input of less than one ampere. It operates without friction, without lubrication, without contact points. Built to outlast the power plant you put it on! Ask for new circular giving complete details.

FOR THIRTY YEARS Stewart-Warner speedometers have been the *standard of comparison in the automotive field.* Today Stewart-Warner precision instruments of many kinds are available for tractors and other machinery. Many of them are being used as original equipment by leading manufacturers of farm machinery.

Insure the greater satisfaction of your customers by using Stewart-Warner Intruments on your machines—to safeguard them against neglect or forgetfulness of the owner, *and to insure longer life and better performance!* Write for complete facts!

TACHOMETERS

Wherever speeds of rotating shafts may vary, Stewart-Warner tachometers will help reduce high operating costs by indicating the most efficient rate of operation.

HAND TACHOMETERS

Small and compact, and incorporating the magnetic principle of Stewart-Warner standard tachometers. Eliminates all guesswork in checking combine speeds; helps cut costs.

SPEEDOMETERS

World-famous for accuracy, Stewart-Warner speedometers are unmatched for reliability. Heavy duty models constructed especially for tractor use; weather-proof.

ODOMETER

Most compact odometer on the market, heavy-duty—built to famous Stewart-Warner standardsofaccuracy. Indicates total miles of operation, including backward as well as forward travel of machine. A positive guide to exact operating costs.

TEMPERATURE GAUGES

Heavy-duty, water and dust-tight. Specially built for tractor use. Show temperatures accurately, so owners can know machines are not overheating.

AMMETERS

Built for heavy duty; weather proof. Tell at a glance the rate at which battery is charging or discharging. Available in different calibrations. Give tractor owners an added sense of security.

OIL PRESSURE GAUGES

Stewart-Warner heavy-duty construction. Dust and water-proof to stand exposure. Any calibration to meet the needs of your machine. Designed to eliminate vibration.

AIR PRESSURE GAUGES

Stewart-Warner precision-built. Record air pressures accurately, with safety factor far beyond actual requirements. Rugged construction; capacities to 400 lbs.

GASOLINE GAUGE

Now it is more important than ever for farm machine owners to know about their fuel supply. This accurate Stewart-Warner gasoline gauge is adaptable to tractor use.

STEWART-WARNER

1800 DIVERSEY PARKWAY • CHICAGO, ILLINOIS

INTERNATIONAL TracTracTors

INTERNATIONAL TracTracTors are built to develop efficient, heavy-duty power at the lowest possible cost. Convenient service, too, stands back of every TracTracTor built by International Harvester. Five TracTracTor models, including two Diesels, give you a complete range of power. Complete details will be supplied on request.

INTERNATIONAL HARVESTER COMPANY
(INCORPORATED)
180 NORTH MICHIGAN AVENUE CHICAGO, ILLINOIS

the BADGE of him who BELONGS

DESPITE the *presumption* it sets up, mere membership in the American Society of Agricultural Engineers is no *proof* of a man's high rank in technical talent. It does prove that he has met certain minimum requirements and has earned the esteem of colleagues who sponsored his application for membership.

But the Society emblem is *evidence* that native talent, be it great or small, is enriched by fraternity with the personalities whose minds fuse to form the pattern of progress in the methods and mechanics of agriculture. The wearer of the emblem waits not for the debut of an idea, but is present at its birth and helps to guide its growth.

Be you novice or veteran, your membership in the organized profession adds something to your efficiency, your vision, your influence as an individual engineer. The Society symbol on your lapel is token that you "belong." Wear it.

STYLES AND PRICES OF ASAE EMBLEMS

With blue ground for Fellows and Members—furnished either in pin with safety clasp or lapel button—$2.00 each.

With red ground for Junior Members, Associates, and Student Members—furnished only in pin with safety clasp—$1.00 each.

Send orders to ASAE, St. Joseph, Michigan.

Agricultural Engineering Digest

(Continued from page 462)

CORROSION OF METALS BY SOME MOTOR FUELS, *A. L. Teodoro and J. P. Mamisao.* Philippine Agr., 26 (1938), No. 9, pp. 774-787, figs. 3. This paper presents data on the effect of alcohol, gasoline, kerosene, and other motor fuels on some metals that are used in the fuel feed systems of internal-combustion engines. The metals used in the present investigation were mild steel, cast iron, aluminum, lead, copper, and galvanized iron. They all measured about 5 by 5 by 0.65 cm, except galvanized iron, which was 0.1 cm thick. Immersions were made for periods covering 100 days (two trials), 200 days, and 350 days.

It was found that mild steel and cast iron are readily and heavily corroded by ether. They show signs of rusting soon after corrosion starts. Corrosion of these metals by the alcohol fuels shows that the higher the water content of the fuel the greater the corrosion. Alcohol fuels containing ether as an admixture are highly corrosive to these metals. Aluminum is heavily corroded by methyl alcohol. It is easily attacked by alcohol fuels and by fuels containing alcohol as an admixture. When corroded it forms a jellylike substance which may clog the fuel passageways and carburetor jets. Lead is heavily attacked by ether and by methyl alcohol and is corroded by all the fuels used in the test. Copper is the only metal tested that is least affected by corrosion. Galvanized iron is corroded by all the fuels used except benzine. It is heavily attacked by ether and by alcohol fuels, especially those containing gasoline and ether as admixtures.

THE SMALL SAWMILL IN NEW YORK, *N. C. Brown.* N. Y. State Col. Forestry, Syracuse Univ., Tech. Pub. 50 (1937), pp. 126, figs. 52. This presents the results of a study of the methods pursued in logging woodlands for small sawmills, together with the manufacturing and merchandising of the product.

The conclusions deal mainly with the economic and general management phases of the subject.

Literature Received

"FARM MACHINERY," by C. Culpin, first edition, 1938. Illustrated, 405 pages, 6x9 in. A British reference and text for farmers and students of agriculture. It includes material on tractors, tillage, plows, implements for the preparation of seed-beds, seed drills, planting machines, row-crop cultivators, manure distributors, hay harvesting machinery, reapers and binders, threshing machines, combine harvesters, root harvesting machinery, drainage machinery, barn machinery, pumps and spraying machinery, dairy machinery, artificial drying of crops, electricity on the farm, farm transport, care and maintenance of farm machinery, and development and economic aspects of the mechanization of agriculture. The appendix includes information on fundamental mechanical principles and simple machines, the transmission of power, friction, lubrication and bearings, measurement of power, materials used in construction of farm machinery, and internal combustion engines. Indexed. Crosby Lockwood and Son, Ltd., London. 18 shillings.

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted." or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS WANTED

AGRICULTURAL ENGINEER with a farm background desires employment in the field of soil erosion control, irrigation, or farm machinery. Educational or demonstrational work preferred. Holds a degree in agricultural engineering. Has one year's experience in highway engineering and four year's experience as a CCC camp engineer for the Soil Conservation Service in the Middle West and Central Atlantic sections. Has had considerable experience in contacting and working with farmers. Employed. Age 29. Married. PW-295

AGRICULTURAL ENGINEER, B. Sc., 1934, Oregon State College. Farm reared, four years experience as engineer with Soil Conservation Service. Desires connection in college or industrial extension, farm machinery or farm management. Single. Age 27 years. PW-296